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Journal of DENTAL RESEARCH

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Editor
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Organized: New York City, Dec. 10, 1920. Of those at the meeting of organization, the following remain active members: Adolph Berger, Theodor Blum, G. W. Clapp, H. S. Dunning, W. J. Gies, A. H. Merritt, B. B. Palmer, L. M. Waugh.

Objects (Const., Art. II): . . . "(a) To promote broadly the advancement of active research in all branches of dental science and in related phases of the sciences that contribute directly to the development of dentistry, and which add to the knowledge of the mouth and teeth and of their relations to the body as a whole; . . . (b) to encourage and facilitate coöperative effort and achievement by, and mutual helpfulness among, investigators in all nations in every division of stomatology; (c) to the end, particularly, that dentistry may render cumulatively more perfect service to humanity." (The Association has been using "dentistry" and "stomatology" as synonyms.)

Membership: total (Nov. 10, 1946), 627. *Eligibility* (*Const., Art. 14, Sec. 1*).—"Any person who has conducted, and published an account of, a meritorious original investigation in dental science, or in any of the sciences contributory to stomatology, shall be eligible to membership in this Association, providing such person conforms to the recognized standards of professional ethics." *Election.*—New members may be elected *only at general meetings of the Association.* Membership in a section is secondary to membership in the Association as a whole. Removal of members from one geographic center to another does not affect their membership in the Association.

Endowment fund of the International Association for Dental Research (as of Mar. 16, 1946): $1,402.98. There have been no expenditures from this fund

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See McBride, *J. D. Res.* **16**: 537, 1937.

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THE EDITOR'S VIEWPOINT

A physical study of some factors involved in inlay and bridge construction is reported by Smyd (p. 649). The physics of the bond (cement) indicate that the cement should be under compressive stress and that where great stress is present large abutments should be used. Since bending varies directly as the cube of the length and inversely as the cube of the depth, a two tooth bridge will bend 8 times as much as a one tooth bridge, unless the two tooth bridge is twice as thick as the one tooth bridge. Consideration of the physical principles and the biological principles involved in prosthetic construction is of great value in aiding restorations to help retention of teeth.

Harper (p. 661) gives the basis for a technic to reproduce the position of teeth on artificial dentures. Noting the relationship of the incisive papilla to the incisor teeth in dentate individuals, Harper utilized this relationship to fix the position of the incisors on artificial dentures and of the maxillary posteriors. Since proper diagnosis is essential in prosthetics as in other phases of dentistry, this suggestion should be welcomed and its implications studied.

Irving and Weinmann (p. 669) injected strontium into rats and found definite changes in the dentin. They describe the calciotraumatic effects and use this opportunity to discuss dentin formation. They propose that the argyrophil fibers (Korff's fibers) swell under influence of the odontoblasts to form afibrillar predentin. Secondarily, fibrils and cementing substance are formed and then "denaturing" proceeds. It is apparent that more definite histochemical studies are in order before the final process of dentin formation is fully explained. Utilization of studies such as this with strontium offer technical approaches.

Engel (p. 681) has refined the histochemical method for demonstration of glycogen and carbohydrate-protein material in developing teeth. Application of this method points out the reason for success in slow decalcification and careful thorough embedding methods for retention of enamel matrix. The importance of this finding should be considered in reviewing Sognnaes paper (*J. D. Res.* 27: 609, 1948). Engel also suggests that certain findings in the protein distribution appear to justify the theory that acid produced on the enamel surface may dissolve the enamel protein. If this is true, the two opposing viewpoints, that is, that caries is initiated as an acid decalcification and that it is initiated as a proteolysis, may be given proper values to support each other.

Investigators using the same basic material often obtain vastly different results. This occurs in bacteriologic, statistical, and chemical studies, among others. Differences in media and culturing condition may be the causes in bacteriology, mathematical methods in statistical studies and chemical methods in analytical studies. Bird, Gallup, Gaudino, and Hodge (p. 693) have compared two methods of ashing tooth structures, incineration and ethylene glycol. They found differences which they attempt to reconcile by calculating the various chemical possibilities. Quite often, studies such as this may offer clues to differences that have been used to build "schools of thought" and resulting scientific differences that may deter progress.

Howell and Manly (p. 705) describe an electronic strain gauge for measurement of oral forces. The need for a gnathodynamometer with a small biting device has been evident for years. There are many instances where bite force measurements are of advantage in research and in practice. The orthodontist and periodontist should welcome this device and it is creditable that engineering and dentistry have cooperated in its development.

The Proceedings of the Twenty-Sixth General Meeting of the International Association of Dental Research presents the abstracts of 163 papers. The increased interest in the

Association, and in dental research in general, has resulted in division of the meeting into sections. While these sectional meetings, which now have resulted in two sections of the biological sciences being conducted concurrently as well as a separate section for the Material Group, have many disadvantages, the program committee has been able to offer no other solution. It is interesting to note that many papers presented by the material group are of interest to the investigators in biological sciences and vice versa. As the Association continues to grow, it may become necessary to limit presentation by more careful selection. Institutions, groups, and individual authors can cooperate by saving their outstanding material for presentation at this meeting and by limiting themselves, each, to a single paper, annually.

H. B. G. R.

Announcements

The Twenty-Seventh General Meeting of the International Association for Dental Research will be held at the Drake Hotel, in Chicago, from June 24 to June 26, 1949.

The American Academy of Oral Pathology will hold its annual meeting at the Hotel Stevens, in Chicago, February 6, 1949.

The Academy of Cleft Palate Prosthesis will hold the annual meeting at Ohio State University, Columbus, Ohio, on March 21 and 22, 1949.

The Proceedings of the Michigan Caries Conference which was published in the *Journal of Dental Research* **27**: 70-113, 223-267, 339-419, 1948, has been republished in book form: Easlick, K.: Dental Caries, Mechanism and Present Control Technics, St. Louis, 1948, The C. V. Mosby Company, pp. 234, price $5.00.

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DENTAL ENGINEERING

E. S. SMYD

Detroit, Mich.

ALL bodies, however rigid or massive they may be, are beyond question deformed by the application of force. No matter how small the forces may be, the deformations are necessarily present. Mastication gives rise to forces which produce deformations of compression, tension, shear, deflection (bending), elongation, and torsion of highly significant magnitude in the investing tissues, the teeth, and restorations.

This paper will be limited to the report of a study of the physics of prosthetic structures which are supported by teeth. Matters pertaining to both, inlays as well as bridges, will be covered in the report; however, since the stresses and strains occurring in prosthetic replacements of multiple teeth are much more significant than those occurring in individual inlays, the mechanics involved in bridge construction will receive emphasis.

DENTAL CEMENTS

The physics of cemented prosthetic structures must be correlated with the physics of the bond.[1] Dental cement is able to take great stress in compression, 13,000 pounds per square inch according to the National Bureau of Standards.[2] Even when the compressive forces of heavy masticatory effort are computed against the small fractions of a square inch which the inlays or abutment castings present to this force, the safe load on dental cement in compression is probably not exceeded. If the abutment castings, however, are so designed as to place the cement in shear or diagonal tension, failure of the bond may occur because brittle substances such as dental or structural cements are weak in these qualities. Tension probably never occurs in the dental bond because dental cements are not adhesive.[3] Fig. 1 illustrates diagonal tension as it occurs in structural cases and Fig. 2, as it might occur in dental cases.

It is interesting to note for purposes of analogy that although structural concrete will take about 3,000 pounds per square inch in compressive stress, engineers use 600 pounds per square inch as a safe figure, 125 pounds in shear, and only 50 pounds in diagonal tension across a 45° angle.

Dental cements act as a bond by a keying action (Fig. 3). When a cemented inlay is placed in direct axial traction, the strength of the cement bond will be determined by the strength of the cement in shear, the roughness of the interface between the inlay and the tooth, the irregularities of the inlay and the tooth, the areas involved in the bond, the pitch or taper between opposing walls of the cavity, and the thickness of the bond. If it be assumed

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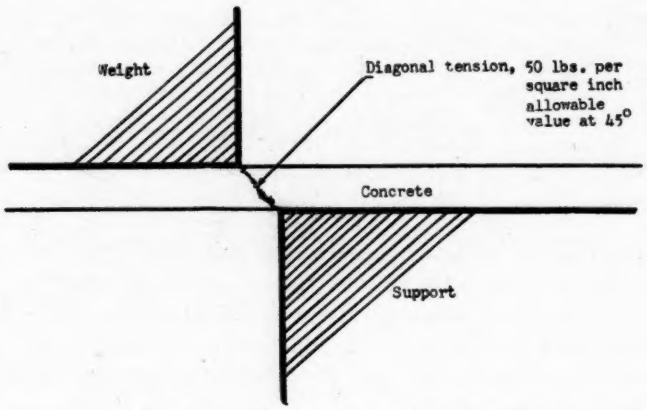

Fig. 1.—Diagram showing diagonal tension on structural concrete.

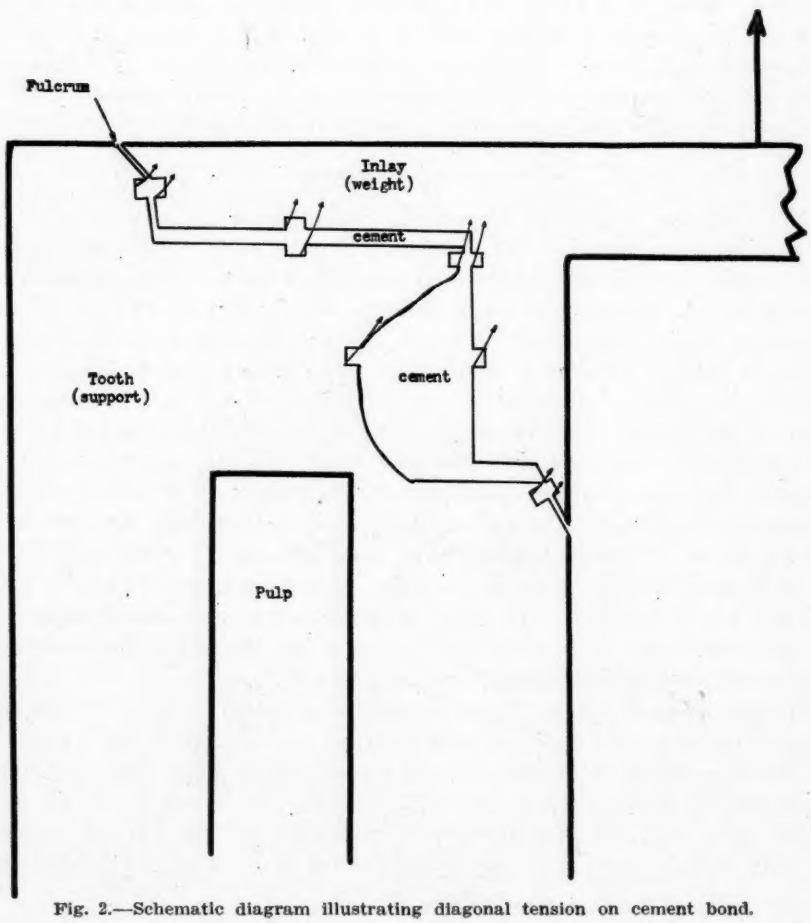

Fig. 2.—Schematic diagram illustrating diagonal tension on cement bond.

for a hypothetical case that the keying of the cement occurs at 90° to the retractile force, the relations of all the factors may be expressed by the equation:[4]

$$\text{Strength of the cement bond} = K.f\left(n,c,A,\frac{1}{d}\right)$$

Where K = a constant denoting shear strength of the cement in bulk
n = number of the projections
c = cross-sectional area of a projection
A = areas of tooth and restoration involved in the bond
d = distance between opposite faces of the bond

From the foregoing equation, n and c become progressively smaller values as casting accuracy and cavity rectitude improve. Since n and c are not at the control of the operator except in a negative sort of way, A and d are the important factors. Two important conclusions follow from this study: (1) It should be regarded as axiomatic that the coupling between the abutment castings and the teeth should be such that the deflection and torsion set up in the prosthetic structure place the cement under the abutment castings in compressive stress. (2) Prosthetic structures which subject the bond to great shear stress should be retained by rather large abutments such as the three-quarter or the full jacket.

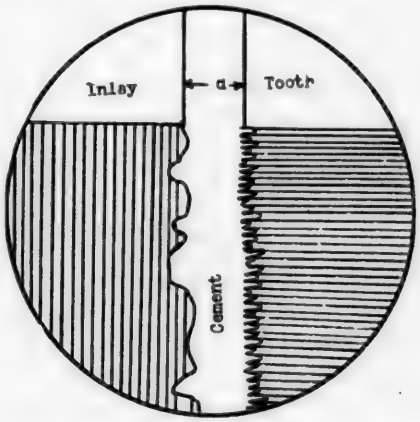

Fig. 3.—Schematic illustration of the factors which maintain the dental bond.

MECHANICS OF PROSTHETIC STRUCTURES

When a prosthetic appliance is subjected to retractile forces, the resultant of such forces tends to produce torque. This is true of retractile forces on individual inlays as well as bridges. Figs. 4 and 5 demonstrate mesiodistal torque. Since the resultant retractile force is exerted through a lever arm, the cement under the abutment casting is under great mechanical disadvantage. If the dovetail be disregarded for the time being, the cement bond between the "box" portion of the inlay and the tooth resists the displacement. From considera-

tions discussed under dental cements, the box type cavity resists displacement better than the "slice" type; and from the conclusion reached in the same study, grooving the axial line angles or reverse beveling of the gingival floor serves to augment resistance form of the cavity for this prosthetic purpose. Reverse beveling is an excellent device for individual restorations, but its value when used for bridge purposes is questionable as it will be seen shortly.

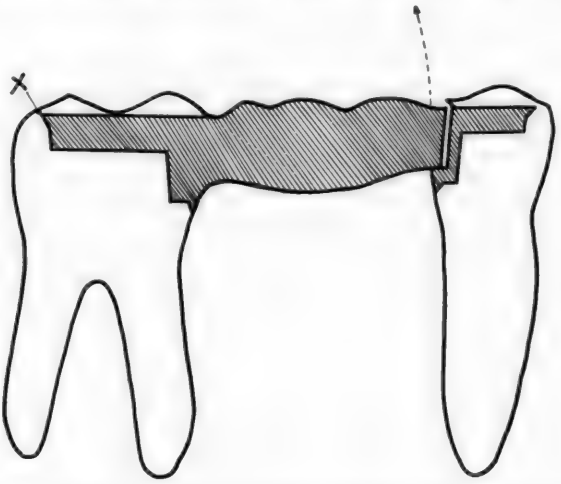

Fig. 4.—"Negative" intermaxillary torque produced by chewing sticky food upon the cantilever.

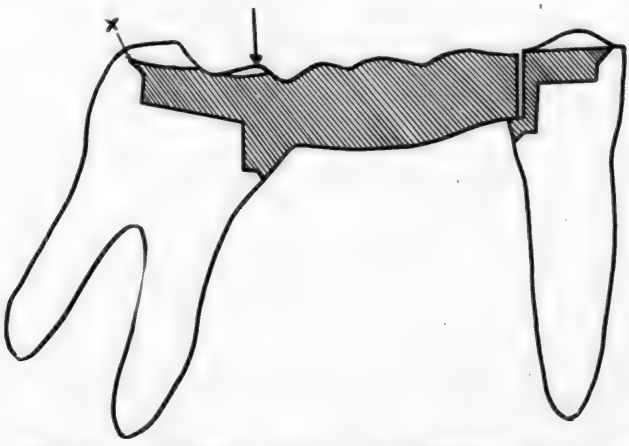

Fig. 5.—"Negative" intermaxillary torque. Counterclockwise rotation with *X* as center occurs when mastication of tough or fibrous food is borne by the cusps of the abutement tooth. The torque tends to pry the bridge structure off the tooth.

The dovetail also may provide mechanical resistance to displacement if it is very "square-cut" or is joined to a dowel in the buccal and/or linqual surfaces of the tooth. The cervical floor of a dowel used in this manner to in-

crease mechanical coupling must be lower than the pulpal floor of the preparation, and for this reason, the dowel-groove must be cut in the buccal or lingual quadrant of the tooth out of proximity of the dental pulp. The efficacy of the dovetail in resisting intermaxillary (mesiodistal) torque may be demonstrated thus:

Fig. 6 represents a sagittal section at a plane where the dovetail of the primary abutment is locked in tooth structure, and Fig. 7 is an enlargement of the dovetail area at this plane. The model used for Fig. 7 is made of plywood. A hole is drilled into the upper edge of the block which represents the dovetail at its mid-point (Fig. 8) to receive the spring-wire rod which will be used to impart torque to A. Figs. 9 and 10 are similarly prepared.

Fig. 7 demonstrates by the deflection of the rod that a dovetail with no pitch is effective coupling to resist torque set up by the counterclockwise movement of the rod, whereas Fig. 9 demonstrates that a dovetail with the pitch shown by *B* will rotate freely to the same force upon a fulcrum established at *X*.

Fig. 10 illustrates that a dovetail with the degree of pitch shown by *C* is also effective in resisting counterclockwise torque.

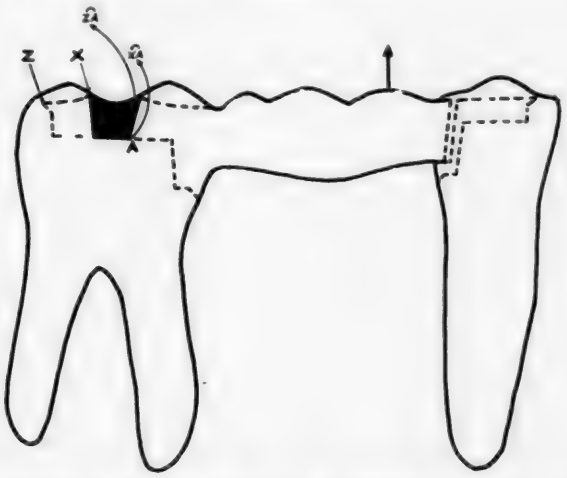

Fig. 6.—Demonstration of the critical pitch of the dovetail with respect to the fulcrum.

This experiment demonstrates the fact that for a given fulcrumage (x in each of the above cases), there is a critical pitch which cannot be exceeded without sacrificing mechanical resistance, but most important, the experiment furnishes us with a tool which has general application and can be used to analyze any case diagrammatically for critical pitch. For instance, if the divider is placed at the fulcrum and the point of greatest rotation of the dovetail opposite is used to establish a radius, *Y* (Fig. 11), one may tell at a glance whether the critical pitch has been exceeded or not by the arc struck from these points. If the arc passes through tooth structure (Fig. 11), the dovetail has mechanical resistance; if through the inlay or cement (Fig. 12), it does not. Fig. 6 shows how much more critical the pitch becomes if the fulcrum is estab-

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 7.—When fulcrumage occurs at *X*, a dovetail with no pitch is effective in resisting torque.

Fig. 8.—Close-up of model construction.

Fig. 9.—This dovetail affords no mechanical coupling.

Fig. 10.—Dovetail with this pitch does afford mechanical coupling.

Figs. 11 and 12.—Experiment establishing the use of radius for the determination of critical pitch.

lished at a point, *Z*, distal to the dovetail. Fig. 13 shows the inefficacy of reverse beveling when a proximoclusal inlay is used as a primary abutment for bridge construction.

Fulcrumage may also occur at *x* of Fig. 14. This may occur in fixed bridge construction when one abutment is looser in the socket than its fellow. By diagrammatic analysis, this kind of fulcrumage presents no problem on the "high" end. The depressed end has already been considered.

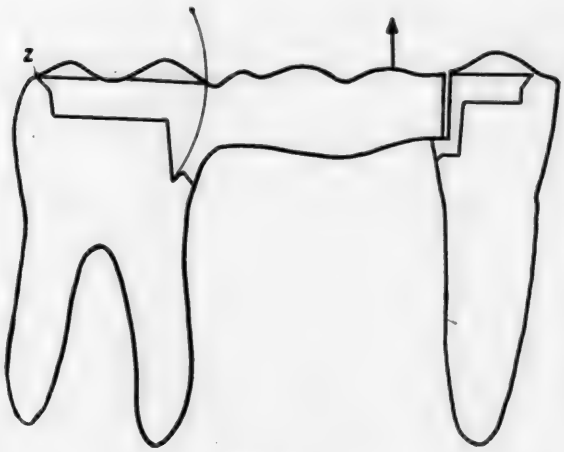

Fig. 13.

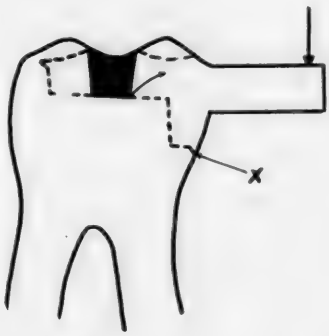

Fig. 14.

Fig. 13.—Diagram showing that reverse beveling fails to provide resistance form to displacement by torque when fulcrumage occurs at *Z*.
Fig. 14.—When fulcrumage occurs at *X*, pitch of dovetail is not critical.

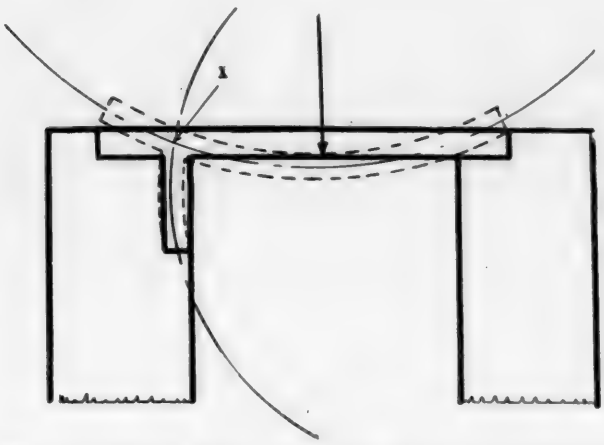

Fig. 15.—Deflection diagram of a loosely coupled or semifixed bridge.

Fig. 15 shows the third point or line where fulcrumage might occur. This concept requires somewhat deeper analysis than the preceding cases.

Stuteville[5] has demonstrated that when teeth are subjected to torque, they turn on an axis which is located in the apical third of the root of the tooth. When a beam or "bridge" is placed across a space from one tooth to another and subjected to load, it bends in a certain characteristic manner and imparts torque to the supporting teeth. The amount of this bending is definitely related to the length of the beam and its depth.

If two slats are cut off of the same piece of 2" × 4" lumber, one being twice as thick as the other, and if they are supported by cross members and loaded at the mid-point as in Fig. 16, the thin slat (Fig. 17) will bend 8 times as much as the thicker one. If the thin slat were one-third the thickness of the other, it would bend 27 times as much. Also, if either one of the slats is loaded with a given weight when the supports are spaced, arbitrarily, two feet apart (Fig. 17), and then again when the supports are one foot apart (Fig. 18), the bending will be 8 times greater at two feet than at one foot. This experiment proves that bending (deflection) varies directly as the cube of the length and inversely as the cube of the depth. The rule covers all substances if the modulus of elasticity of a given substance in tension equals or approximates its modulus in compression; therefore, the rule applies to all such substances as wood, steel, gold alloys, other metals and their alloys. All other things remaining equal, a two-tooth bridge will bend 8 times as much as a one-tooth bridge, and a three-tooth bridge will bend 27 times as much. Likewise since bending varies, though inversely, as the cubed power of the depth, a bridge having a thick section from occlusal to gingival will bend ⅛ as much as a bridge having half this depth. The stiffness of the isthmus and box or flange of an inlay is similarly related to length and depth.[6]

Extreme flexibility of the bridge structure and inadequate bracing of the abutment castings may result in sufficient torsion of the abutment inlays to produce loosening. The most significant bending of the inlays, will occur at the intersection of the neutral axes of the bridge span and the supports, *x*, of Fig. 15.

A series of cardboard models were cut to demonstrate bridge deflections. Cardboard supports were made to simulate teeth, and these were pinned to a drawing board at the supposed axes of rotation. The effects of thin sections in the abutment castings as in thin pin-ledge and slice preparations were studied by this method. Also studied by this method was the "MOD" type of anchorage, the effect of tipped abutment teeth upon the deflection of the structure, and thick and thin bridge spans[7] (Figs. 19, 20, 21).

Fig. 22 illustrates bridge deflection on a wooden model, and Fig. 23 demonstrates the efficacy of doweling. In practice, of course, the dowel would consist of a semicylinder of metal resting in a groove in the buccal or lingual tooth structure.

When fulcrumage occurs at the intersection of the neutral axes of the bridge span and the support, the pitch of the cavity walls is very critical. Fig. 24 illustrates that the critical pitch of the dovetail is absolute perpendicularity with respect to the long axis of the bridge structure. It has been demonstrated by the cardboard models, the wooden model, and here it is shown

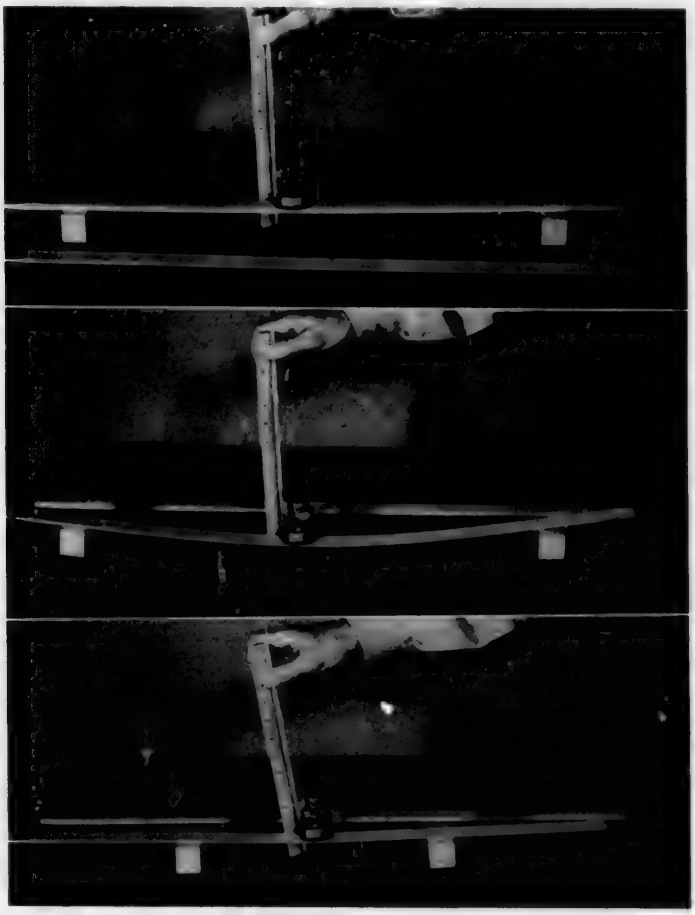

Fig. 16

Fig. 17

Fig. 18

Fig. 16.—The deflection of ¼" slat to a given weight when freely supported. The supports are two feet apart.
Fig. 17.—The deflection of ⅛" slat to the same weight with supports spaced two feet apart.
Fig. 18.—The deflection of ⅛" slat to the same weight with supports spaced one foot apart.

diagrammatically, that if the dovetail ends with a dowel in a buccal or lingual groove whose cervical floor is at a lower plane than the pulpal floor, the abutment casting becomes mechanically coupled. The same effect is achieved by the external "rib" or "web" of metal of the three-quarter crown.

Fig. 19

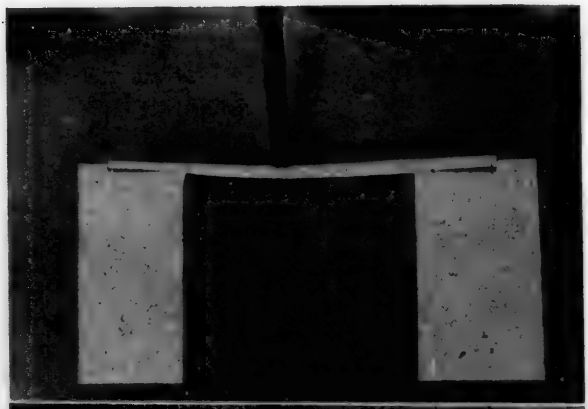

Fig. 20

Fig. 21

Fig. 19.—Cardboard model illustrating bridge deflection when abutment with thin flanges are used (pin-ledges, thin proximocclusals).

Fig. 20.—Cardboard model showing deflection of "MOD" type of abutment and immobilization produced by dowel at right.

Fig. 21.—Cardboard model showing deflection of bridge when supported on tipped abutments.

Fig. 22.—Wooden model illustrating characteristic deflection of fixed bridge.

Fig. 23.—Same model as Fig. 22, demonstrating the efficacy of vertical dowels.

Fig. 24.—Diagram summarizing the critical pitch of the dovetail when torque produces fulcrumage at *A*, *D*, or *Q*.

Fig. 22.

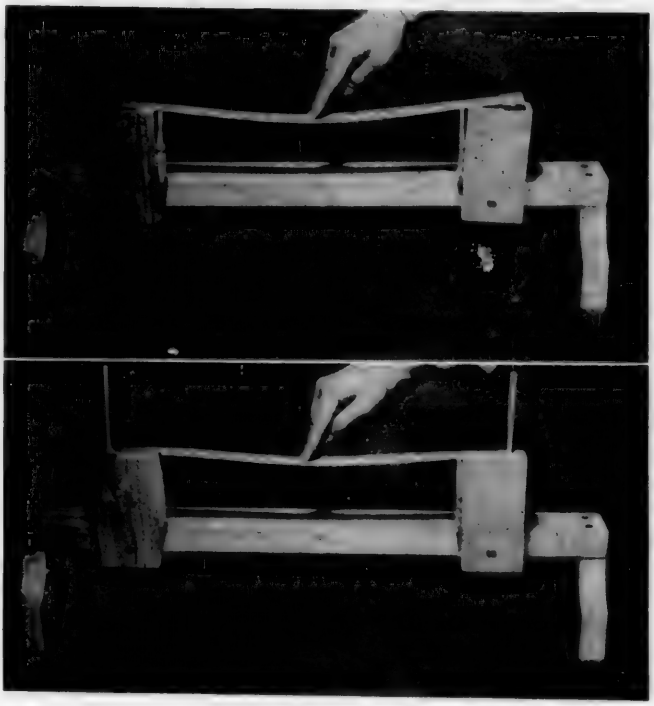

Fig. 23.

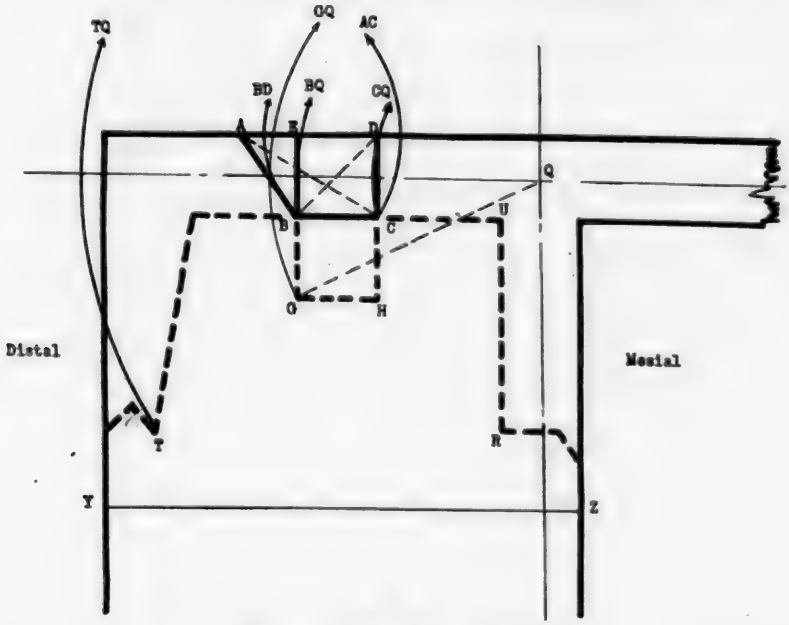

Fig. 24.

(See opposite page for legends.)

CONCLUSIONS

For physical as well as biological reasons, abutment inlays should be large, relatively thin, but well braced. Bracing of the box and isthmus is best done by an external rib or web of metal as exemplified by the three-quarter crown. Since the management of abutment castings, especially extensive and thin ones, is best done on substantial metal facsimiles of the prepared teeth, indirect methods derive support from the study. Whatever the indirect method may be, it must, however, afford a close tolerance between the abutment casting and the tooth. It can be proved by mechanical analysis that the bending moment at the support of the primary abutment of a bridge which is loosely coupled at the secondary abutment is greater than the bending moments at either of the supports of a completely fixed bridge; however, if a relatively small primary abutment is sought, the cavity should at least incorporate axial grooves and a dovetail dowel-groove on the lingual or buccal surface whose cervical floor is at a plane lower than that of the pulpal floor of the preparation.

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THE INCISIVE PAPILLA

The Basis of a Technic to Reproduce the Positions of Key Teeth in Prosthodontia

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IN THE treatment of the edentulous patient, it is essential that the dentist possess sufficient diagnostic data to enable him to locate the spatial planes on which the incisal edge of a first incisor and the occlusal surfaces of several maxillary posterior teeth rested in the natural dentition. Three planes are involved: (1) the vertical planes of the labial surface of the first incisor and the buccal surfaces of the posterior teeth; (2) the horizontal planes of the incisal edges of the first incisors and of the occlusal surfaces of the posterior teeth at the points where they intercept their respective vertical planes; (3) the sagittal plane in its relation to the mesial surface of the first incisor.

There is a definite relationship of these planes to the planes of other maxillary parts visible in the individual with teeth which is affected by an edentulous condition. With the use of mechanical planes, from which parallel and perpendicular measurements can be made, the relationship of the planes of the teeth to the planes of the stable parts can be recorded on these mechanical planes. Thus, in the treatment of the edentulous patient, the artificial teeth can be placed in natural positions by setting them on the denture as recorded by the mechanical planes.

In studying the maxilla to select these stable parts, it was found that the palate presents a median raphe, which ends anteriorly in the incisive papilla. The incisive papilla is a small, pear-shaped eminence composed of relatively unyielding tissue designed to act as a protective covering to the underlying incisive foramen. It is situated on the median line of the palate, and in the dentate it is just back of the first incisors. On the edentulous ridge, after resorption has occurred, it is located distally to, or on, the center of the ridge.

In the older textbooks on prosthesis, the papilla is not mentioned, and the only consideration given to it in modern textbooks is its location and instructions concerning denture pressure in this area. This is to be expected for the papilla has never been utilized in any denture technic. If it is demonstrated that the incisive papilla is a dependable basis for a technic that will make it possible to diagnose the original positions of certain key teeth in the process of treating edentulous individuals, it will serve as more than just an anatomical landmark. When artificial teeth are set in proper positions, which may be determined from the incisive papilla, the foundation is correctly laid for natural speech, pleasing appearances, and normal function.

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At the present time, the only accurate method for reproducing the position of any of the natural teeth is the use of immediate dentures. Even when immediate dentures are advisable, the need of relocating the natural position of these teeth is still a problem in constructing the second set.

Before the papilla was accepted as a basis for a denture technic, some study was done on the papilla itself. The following results were obtained. (1) No relief for the papilla is necessary or indicated on the denture. (2) While the papilla is always on the median raphe, it cannot be depended upon as a guide in marking the median line in edentulous cases. It was found in the examination of a number of dentate individuals that, while in the large majority of them a line through the center of the papilla is continuous with the median line, in only 58 per cent of these persons was this continuous papilla-median line in the center of the face. This indicates that in almost one-half of the population, the maxilla is orientated in an off-center position within the skull. This may be due to a bodily shift of the maxilla to one side, with the median raphe perpendicular to the ridge, or a pivital shift with an inclination of the raphe. Such conditions are in keeping with the diversity of the growth pattern. In other cases, representing a very small percentage of those examined, the papilla alone was in the center of the face. Also representing another small percentage were those cases in which the papilla line was not in line with the median line or the facial center. (3) It was found that the distance from the papilla to the incisal edges of the first incisors varies with individuals in both the vertical and horizontal planes; that the distance from the papilla to the necks of the first incisors varies with individual cases in both planes. It was further found that the distance from the papilla to the right and left first incisors in some individuals varies in the horizontal plane. (4) If the horizontal distance measurements made at right angles from the incisal edges of the upper first incisors to the center of the papilla is not less than 5 mm. and not more than 8 mm., these teeth in such cases will have a normal inclination. (5) It was also ascertained that if a vertical plane is projected across the center of the papilla and it passes within the anterior half of the canines, the anterior portion of the arch will have a normal contour and when such a plane passes through the distal half of the canine, the arch will be flat. (6) There is no change in the position or dimensions of the papilla or the median raphe in a mouth from the dentate stage to the edentulous stage. The palate, on which these two stable maxillary parts are located, is a hard bone and is not, as is the alveolar process, subject to resorption.

Actual proof that the papilla is stable was obtained by measurements on preextraction and postresorption models of the same cases. In two cases the time between the recording of the models was over seven years. Stability of the horizontal position was proved by comparative measurements with calipers.

In proving the stability of the vertical position, it was necessary to mount the models so that the planes of like sections of the median raphe of both models were parallel. This was accomplished by adding a specially designed attachment to a Ney surveyor. The vertical measurements were made with the denture gauge, parallel relationship being maintained with the addition of a spirit level.

Comparison demonstrated the stability of the vertical position of the papilla.

Based on this study, these deductions have been made. 1. The incisive papilla is a dependable basis for a technic designed to reproduce the horizontal and vertical position of the maxillary first incisor. 2. The incisive papilla is a dependable basis for a technic to reproduce the height of the natural occlusal plane. 3. The incisive papilla affords a dependable basis for a technic designed to obtain the correct vertical dimension in full upper dentures. 4. The imprint of the incisive papilla is a dependable basis for the following: (a) measuring the height of the first incisors above the ridge of a denture; (b) to reproduce the position of the upper first incisors from an immediate denture; (c) to maintain, during the process of setting up the first incisors, the length as well as the anterior-posterior position, as recorded by the bite rim. 5. The incisive papilla is a dependable basis for a technic designed to make a scientific study of any change in the height of the teeth and/or, any selected portion of the maxillary process.

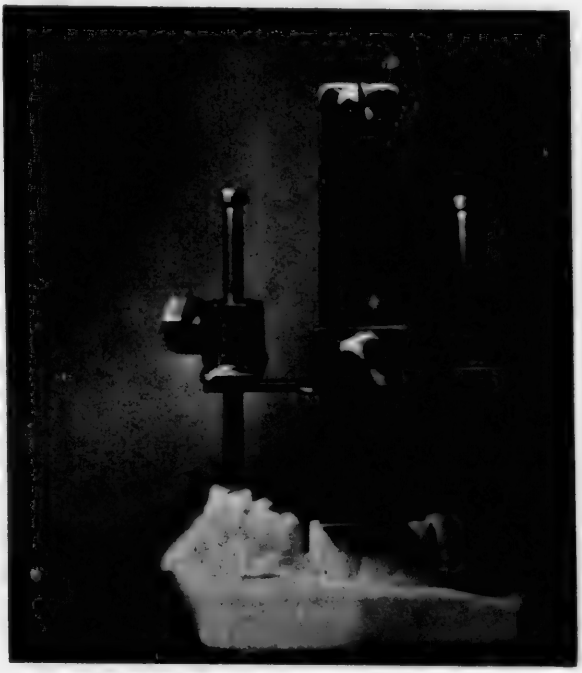

Fig. 1.—The height of the first incisor above the incisal papilla on the record model is denoted in millimeters on the inner surface of the vertical arm of the "Denture Gauge," while the distance the incisal edge is anterior to the selected spot on the papilla is denoted in millimeters on the under surface of the incisal table. The relationship to the center line of the first incisors to the center line on the table can also be recorded.

TECHNICAL PROCEDURE

1. *Using the Incisive Papilla as a Basis for Reproducing the Natural Position of the First Incisors.*—On the record model, the incisal edges of the first incisors are a definite distance above and anterior to the incisive papilla, which

in turn has a definite horizontal and vertical distance relationship to any point on the median raphe. On the edentulous model of the same individual, there are only the papilla and the points on the median raphe, which, because their positions are stable, still have the same horizontal and vertical distance relationship to each other. Therefore, one leg of a gauge can be placed on the papilla and the other leg on a point on the median line of the record model in such a manner that when the gauge is transferred to the same spots on the edentulous model, the measuring arm of the gauge will be in the same relationship to the points on this model as it was on the record model.

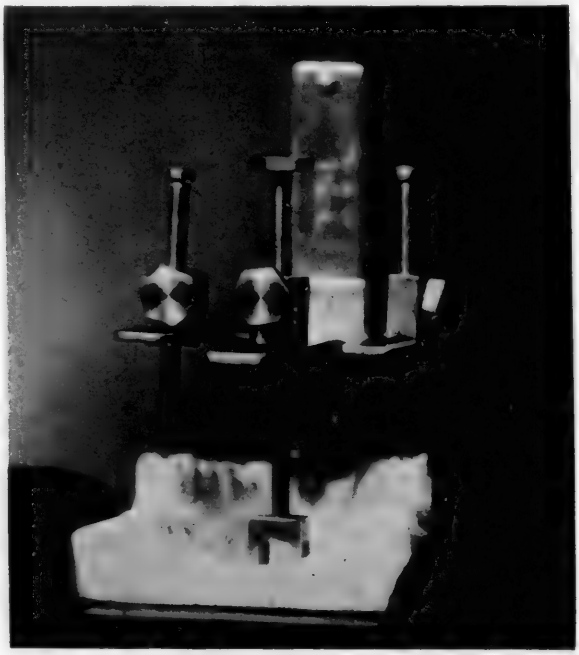

Fig. 2.—By transferring the gauge, as set on this record model to the same position on the model of the new edentulous maxilla, the natural height of the occlusal plane as well as the natural width of the arch will be reproduced at this and other selected spots. This will also reproduce the natural compensating curve.

This assures that, when we measure with the gauge, the horizontal and vertical distance from the papilla to the incisal edges on the first model (Fig. 1) and then transfer the gauge over to the second model with the palatal and papilla pins penetrating the base plate, we will be in position to set the artificial first incisors in the same position as was once occupied by the natural first incisors.

In those cases in which the median raphe is not distinguishable, it is necessary, in order to maintain the required relationships with the sagittal plane, to do the following: (a) record and extend the sagittal relationship of the center line of the incisal table on the gauge, with the frenum, center line of first

incisors, and center of papilla, or (b) inscribe intersecting arcs on both models, from the same spots on the rugae to the center of the palate in the posterior region.

2. *Using the Incisal Papilla to Establish the Natural Height of the Occlusal Plane.*—Just as the position of the incisal edges of the first incisors, which establishes the individual normal height of the occlusal plane in the anterior region, can be reproduced, with the use of the occlusal plane attachment (Fig. 2), can the position of any selected spot on a posterior tooth be reproduced and thereby the normal height of the plane in the posterior region be established. The height of the occlusal plane seldom is the same on right and left sides of an dividual, but varies from 1 to 5 millimeters. Vertical survey also demonstrates that use of the curve of Spee is very slight in the premolar region, varying from 0 to 1 mm., with an increase rise in the molar region to 2.50 to 5 millimeters.

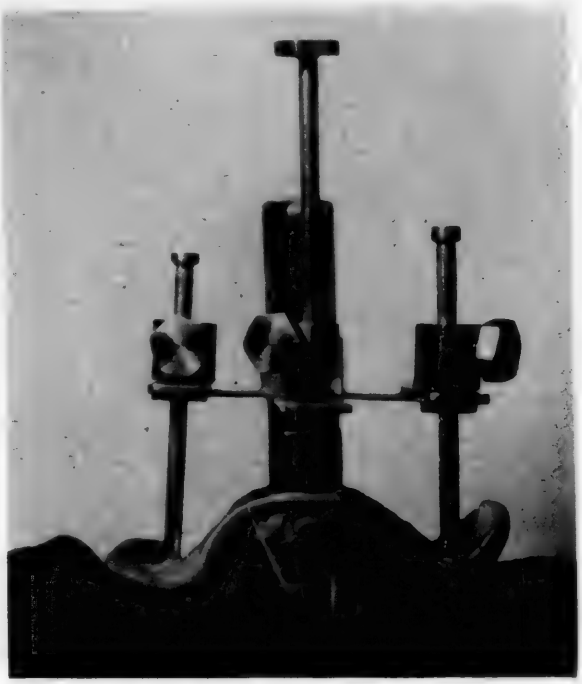

Fig. 3.—By placing the papilla and palatal pins in the same positions on the new base plate as they are on this immediate denture, the natural difference in the height of the occlusal plane on the right and left sides will be reproduced. The foot of the palatal pin is so designed to meet the requirements of the various formations of the median raphes.

3. *Using the Incisal Papilla to Register the Correct Vertical Dimension.*—In constructing a complete upper denture, when one or more natural or artificial lower posteriors are present, registration of the correct vertical dimension can be assured because the gauge can be set in position on the record model, and the occlusal-plane pins can be adjusted to rest on spots that are a part of the

surface that maintains the upper portion of the denture space. With the gauge in position on the edentulous model, the bite rim is built to contact the occlusal pins, and it is assured that these spots on the bite rim are on the same vertical and horizontal planes as the selected spots are on the record model.

4. *Utilizing the Imprint of the Incisive Papilla.*—

(A) Obtaining the measurements on an old denture or a partial or immediate denture and transferring them to the base plate of a new denture: All known methods of measuring the degree of vertical distance between the incisal edges of the upper first incisors of a denture and the ridge surface fail, due to parallactic errors. Such errors easily occur because the instrument does not form right angles with the surface of the denture and the incisal edges. Accurate measurements can be obtained only when the parallel planes of these two surfaces have been located, and the gauge set perpendicular to the planes.

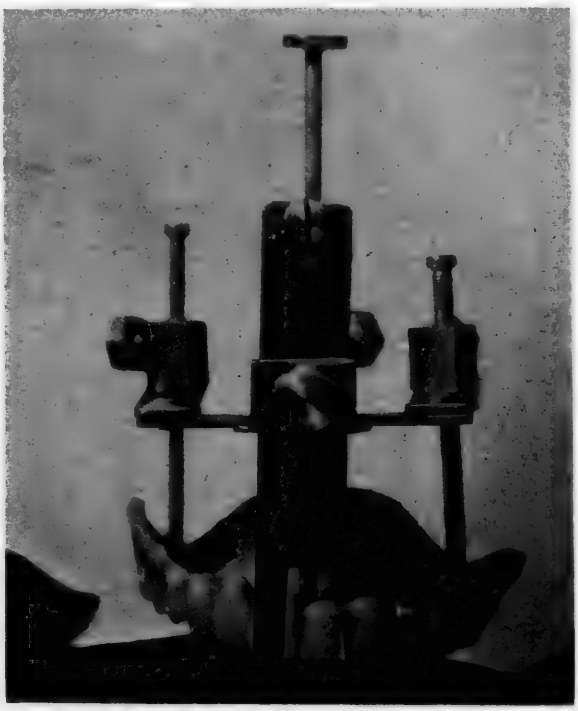

Fig. 4.—Length of the first incisor above the ridge is denoted in millimeters below the collar on the vertical arm, while the distance the incisal edge is anterior to the selected spot on the papilla is denoted on the top surface of the incisal table. The purpose of the window in the vertical arm is to facilitate setting the incisors on the base plate. The shoulder of the papilla pin is flush with the papilla depression but its pointed end does not show as it is counter sunk for stability of the gauge.

To accomplish this, it is essential that: (1) Two areas of adequate size, on the palatal side of the denture, the surfaces of which are parallel, must be located. (2) In order to transfer measurements from the old to the new base, one of these areas must be distinguishable and both must be stable.

Such areas are the imprint of the papilla, which is always distinguishable, and the section of the median raphe anterior to the postdam position which, when it is not distinguishable, is located by an upright position of the palatal pin of the gauge as viewed from the posterior of the denture (Fig. 3). Therefore when the posterior leg, or the palatal pin, is adjusted until both feet are flush with the underlying palatal area and in an upright position, and the anterior leg, or the papilla pin, is resting flat within the papilla depression, the gauge will have denoted the parallel surfaces. As the recording arm forms a right angle with the pins, it will be parallel to the ridge surfaces adjacent to papilla depression and at right angles to the incisal edges (Fig. 4).

In obtaining the posterior height of the occlusal plane, the occlusal-plane arm is adjusted until the occlusal-plane pin rests on a selected spot on the ridge surface of the denture. This can be done on either or both sides. The height of the occlusal plane is then obtained by measuring with a Boley gauge from the occlusal-plane arm to a spot on the occlusal surface directly under the pin. The new bite rim is then built to this height at this same spot.

If there has been ridge shrinkage at this spot during the time that has elapsed between the construction of the old and new dentures, it will be indicated, when only one occlusal-plane pin is used, by a lack of contact with the base plate of the foot of the palatal pin next to the occlusal-plane pin. In such instances, when measurements are made on both sides, both feet of the palatal pin will be raised above the base plate. This is due to the decrease in the height of the ridge surfaces above that of the palatal surface. When such a condition is vident, the occlusal-plane pin or pins must be shortened until both feet of the palatal pin rest on the base plate.

(B) Measurements to prevent laboratory errors: The theory is the same, and the purpose is to prevent a change in the position of the incisal edges of the first incisors from that recorded by the bite rim of the base plate.

(1) It has been suggested that the anterior-posterior inclination of the edentulous maxillary ridge varies with the individual and that the normal slant of the long axis of the first incisors is determined by this individual inclination. Therefore, when the position of the incisal edges is recorded in a mouth on a bite rim, the ridge inclination of which is –15° (heels below the horizontal) and the maxillary cast is mounted in the customary laboratory method, the inclination of which is + 2° (heels slightly above the horizontal), it will so alter the perspective from the technician's point of view that he may deem it expedient to change the slant of the first incisors from that recorded by the bite rim. This will not only change the anterior-posterior position of the incisal edge, but also the length.

(2) Another mistake that causes a change in the length of the upper anteriors from that recorded at the chair occurs in those cases in which the technician finds that it is necessary or expedient to change the anterior-posterior position of the first incisors from that recorded. This error is similar to that just mentioned (1). It is caused by the laboratory method of recording the length from a set line on the model, or articulator arm, to the edge of the bite rim. When any change is made in the horizontal position of the incisal edges,

it will alter the length because the measuring device is compelled to travel in an arc. When the first incisors are moved closer to the ridge, they will be elongated and when they are moved in the opposite direction, they will be preshortened. These errors can be prevented by the use of the principles of right angles' measurements.

5. *Using the Incisal Papilla to Study Points on the Maxilla That Are of Interest in Denture Construction.*—

(A) Since the papilla has a definite vertical and horizontal relationship to all points that create the compensating curve, an accurate survey of comparative height and horizontal distance from the papilla to these points could be made with the gauge.

(B) It also would be possible to measure the distance that posterior teeth which have not obtained their full length, due to the inharmonious relationship between the normal eruption length and the degree of posterior interdental space, will grow below the occlusal plane when the space is increased by the loss of the lower occluding posterior teeth.

We know this phenomenon changes the vertical position of the posterior region of the plane. But we do not know the degree of change or whether the relationship to the anterior region is normal before or after the full growth of the upper posteriors.

SUMMARY AND CONCLUSIONS

The positional relationship of the incisive papilla to the teeth presents valuable diagnostic data in the treatment of the edentulous patient.

Sufficient study has been made to prove that this relationship can be used to reproduce from a record model or a denture, immediate or partial, the position of key teeth, such as: (a) the natural maxillary first incisors, thereby maintaining facial appearances and normal speech; (b) the natural maxillary posteriors for a correct diagnosis of the position of the individual normal occlusal plane and compensating curve.

Study can and should be made on: (a) degree of normal resorption and abnormal resorption under tissue bearing appliances; (b) the growth of certain posterior teeth below the occlusal plane; (c) the correlation of the median line of a denture with the facial center when this center line deviates with the natural median line.

EXPERIMENTAL STUDIES IN CALCIFICATION

VI. Response of Dentin of the Rat Incisor to Injections of Strontium

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IN 1911 Erdheim[1] suggested that the rat incisor might be used as a kymograph in mineral metabolism, since the dentin, which is deposited and calcified continuously during the life of the animal, is altered in a characteristic and histologically well-defined way if disturbances in mineral metabolism occur. The present paper reports the analysis of the typical response of the dentin to disturbances of the mineral metabolism. The timing and location of this response make it suitable for use as a chronological reference point in the study of a great number of different experimental procedures. The structural analysis of the dentin changes permits, furthermore, a broadening of our concept of dentinogenesis.

REVIEW OF LITERATURE

For many years evidence has accumulated that dentin during its development reacts in a characteristic way to a wide number of injurious agents. In 1934, Schour and Smith[2] noted that fluorine administration caused a hypocalcified layer followed by a hypercalcified zone. The same effect was found by Schour and Ham[3] and Schour, Tweedy, and McJunkin[4] following administration of calciferol or parathyroid hormone. In 1937, Schour, Chandler, and Tweedy[5, 6] and Schour, Tweedy, Chandler, and Engel[7] found that an identical pattern was caused by parathyroid hormone and immediately after parathyroidectomy. These workers noted, in addition to these two layers, a fine deeply stained line bordering the outer edge of the hypocalcified zone which they called the calciotraumatic line. A re-examination of the neonatal line[8] in the dentin shows it to have a similar pattern, and the same is true of the contour lines of Owen.

Applebaum[9] showed by grenz-ray studies that the areas staining histologically as hypo- and hypercalcified were in fact radiolucent and radiopaque. In 1943, Irving[10] analyzed the time relations of these layers after fluorine administration and showed that the border of the hypo- and hypercalcified zones corresponded to the junction of pre-experimental and experimental dentin.

Klein, Becker, and McCollum[11] had reported striations in the dentin of the incisor teeth of rats which had been fed adequate diets alternately with and without strontium. Weinmann[12, 13] noted that subcutaneous injections of strontium chloride produced marked changes in the dentin similar to those caused by the other procedures described. His work was therefore extended and further analyzed since the intense reactions found appeared to be ideal for a closer analysis of the phenomenon.

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The present study on the effect of strontium goes one step further than the one on fluorine.[10] While in the latter, emphasis was put on the time of occurrence of the different layers, the present investigation attempts, in addition, to analyze the structural characteristics of the altered pathologic dentin.

The strontium injections also produced enamel hypoplasia and typical changes in the enamel organ. These already have been reported by Weinmann.[13]

METHODS AND MATERIAL

The present report is based on studies of the upper incisors of 15 experimental albino rats ranging in age from 39 to 61 days and 2 litter-mate controls (Table I). A large number of additional normal rats of previous investigations were also used as controls. The animals were of the Wistar Institute strain and were fed dog chow (Purina) after weaning at 21 days.

TABLE I

EXPERIMENTAL DATA AND FINDINGS IN THE DENTIN OF THE INCISOR OF RATS GIVEN ONE INJECTION OF 1 C.C. OF TWENTY PER CENT STRONTIUM CHLORIDE SOLUTION ($SrCl_2 \cdot 6H_2O$)

NUMBER AND SEX OF ANIMAL	AGE IN DAYS AT THE BEGINNING OF THE EXPERIMENT	WEIGHT AT DEATH IN GM.	MG. STRONTIUM PER KG. BODY WEIGHT INJECTED	DURATION OF EXPERIMENT IN HOURS	PREDENTIN IN μ	NORMAL CALCIFIED DENTIN IN μ	HYPERCALCIFIED LAYER IN μ	HYPOCALCIFIED LAYER IN μ	DISTANCE IN μ FROM THE PULP TO THE	
									EXPERIMENTAL DENTIN LINE	CALCIOTRAUMATIC LINE
430	51	178	—	—	14	Not measured	—	—	—	—
431	51	180	—	—	14	Not measured	—	—	—	—
426 M	51	178	363	3½	18	0	0	0	0	0
427 M	51	176	363	7½	16	0	0	0	0	—
428 M	51	202	330	14½	—	0	7	16	7	23
429 M	51	198	330	19	—	0	10	13	10	23
140 M	42	89	825	24	4	0	12	13	16	29
453 F	61	128	495	28	5	0	16	14	21	35
148 F	39	79	825	32½	7	0	16	14	26	40
131 F	42	66	825	45	17	0	10	12	27	39
454 M	61	121	528	52	17	9	13	10	39	49
132 M	42	87	825	53	16	12	12	12	39	51
146 F	39	74	825	72	14	12	14	0	38	47
455 F	61	109	594	72	14	14	13	12	42	53
456	61	110	594	96	10	39	12	13	61	74
457	61	100	660	168	12	68	12	10	91	101
458	61	98	660	192	13	92	13	12	118	130

The rats each were given a single subcutaneous injection of 1 c.c. of 20 per cent strontium chloride and were killed with chloroform at intervals varying from three hours to eight days after the injection. As the animals varied in weight, the ratio of the injected amount of strontium to the weight differed (Table I). Each animal developed a necrosis of the skin at the area of the injection, and showed a slight drop in weight, but no other pathologic symptoms were observed.

The heads of the rats were fixed in Zenker-formalin solution for one day, or in Bouin's solution for two days. Specimens were decalcified in 5 per cent nitric

acid, embedded in celloidin, stained with hematoxylin-eosin or impregnated with silver (Gomori[14]).

Measurements (Table I).—Using a filar micrometer eyepiece, the following distances were measured in various parts of the labial side of the incisor: 1. The width of the predentin; 2. The distance of the junction of the hypo- and hypercalcified layers from the pulpal edge of the predentin; 3. The distance of the calciotraumatic line from the pulp.

ANALYSIS OF STAINING METHODS

Hematoxylin and Eosin Stain.—Hematoxylin-eosin stain is so widely used in work of this kind that little need be said of it here. Schour and Ham[3] showed that areas staining predominantly with hematoxylin are calcified and those staining with eosin are poorly calcified or not calcified. This applies to tissues whether decalcified or not during preparation for histological sections.[15] Applebaum,[9] as already mentioned, showed by Grenz-ray studies that this interpretation of the staining reactions was justified.

Silver Stain.—The silver is precipitated particularly well in the precollagenous fibrils so that the Korff's fibers are seen as black lines. It also stains well the walls of the dentin tubules (Neumann's sheath). Collagenous fibers and fibrils stain well, but less intensively, than the precollagenous ones and are as a rule colored brown. By contrast, the calcified interfibrillar cementing substance does not stain at all.

In a silver-impregnated section the predentin is separable into two layers which are not sharply delimited from each other. The inner or most recently formed layer, referred to as young predentin, stains evenly dark brown with silver, while the outer or the older layer, referred to as old predentin, appears lighter brown. In the older layer the sharply stained fibrils are seen embedded in the lightly stained cementing substance. These findings suggest that the predentin is primarily homogeneous and that the differentiation of its fibrils and their separation from the cementing substance occurs secondarily. These two layers of the predentin seem to correspond to the "early" and "late" predentin as described by Schour and Rogoff,[16] which stain differently with eosin. The "late" predentin stains pink with eosin, the "early" predentin remains almost unstained.

In calcified dentin the cementing substance which holds the lime salts stains well with hematoxylin and poorly with silver. Quite generally it can be stated that highly basophilic structures are argyrophobic. This applies to other tissues as well as to dentin. In the development of the enamel, the single enamel rod undergoes a series of changes which can be differentiated by staining reactions. In an early state of formation of the rod, the Tomes' process becomes homogenous. At this stage it does not stain with hematoxylin but stains intensively dark with silver. The reverse is true in the following stage of the formation of the enamel rod; the so-called pre-enamel matrix stains intensively with hematoxylin but does not react to silver.[17] A similar antagonism has been observed in the histology of bone. Resting lines are stained by hematoxylin but not with silver. Sharpey's bundle bone stains more intensively with hematoxylin and less intensively with silver than lamellated bone.[18]

These characteristics of the silver stain also apply in abnormally developed dentin and have been found to be of considerable assistance in the interpretation of the present data.

FINDINGS

The reactions of the dentin to the injection of strontium were, in general, the same as those after injection of fluorine. They consisted of a calciotraumatic line, a hypocalcified layer, and a hypercalcified zone.

Hematoxylin-Eosin Staining.—Animals sacrificed fourteen and one-half hours after the injection showed the earliest reaction to strontium. Only the middle third of the tooth was affected. Here the zone normally occupied by predentin now consisted of two layers (Fig. 1, *A* and *B*). The inner layer stained intensively with hematoxylin and could therefore be recognized as hypercalcified. It extended right up to the odontoblasts, no predentin in the accepted sense being present. The outer layer stained poorly with hematoxylin, hence it seemed to be hypocalcified. It was bordered on its outer edge by a calciotraumatic line, separating it from normally formed and calcified dentin. The calciotraumatic line was 23 microns distant from the pulpal surface. The hypocalcified layer was 16 microns wide and the hypercalcified layer, 7 microns.

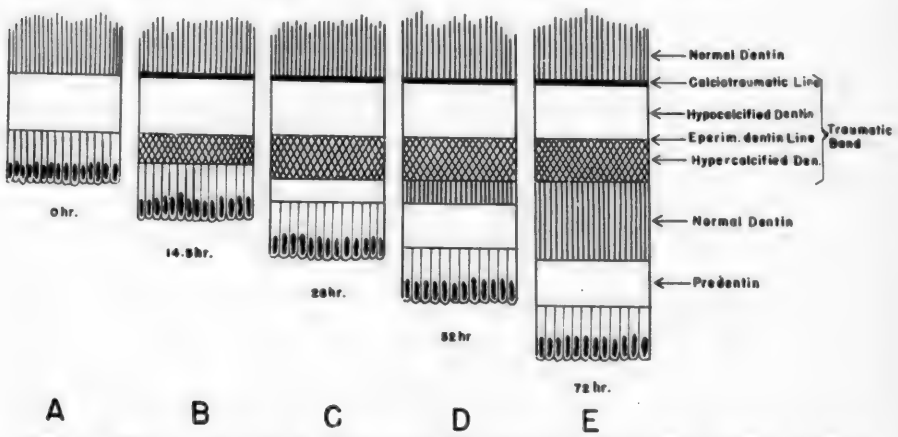

Fig. 1.—Diagram showing development of calciotraumatic band after injection of strontium. Note constancy of experimental dentin line, that is, boundary between pre-experimental and experimental dentin:

A. At beginning of experiment. Note layer of predentin adjacent to odontoblast layer.

B. Fourteen and one-half hours after injection. Note calciotraumatic line between pre-experimental predentin and normal dentin, and layer of hypercalcified dentin adjacent to odontoblasts. The pre-experimental predentin has not calcified.

C. Twenty-eight hours after injection. Note that calciotraumatic line and hypocalcified layer are unchanged. The hypercalcified layer has increased in thickness and a new layer of predentin has formed.

D. Fifty-two hours after injection. Note that calciotraumatic line, hypocalcified layer, and hypercalcified layer are unchanged. The predentin of *C* has calcified and a new layer of predentin which is of normal thickness has been formed.

E. After seventy-two hours. Note that formation and calcification of dentin progresses normally.

After twenty-eight hours (Figs. 1, *C* and 2), the zone of reaction had been separated from the pulp by the formation of a new layer of predentin. The affected zone extended to the formative end of the tooth where it could be seen indistinctly. The calciotraumatic line was 35 microns from the pulpal surface.

The hypocalcified layer remained virtually unchanged in thickness, but the hypercalcified stripe had increased in width from 7 to 16 microns. Typical predentin had now begun to reappear and was 5 microns in width.

After fifty-two hours (Fig. 1, *D*), the reaction was equally intense along the entire labial side of the tooth. The calciotraumatic line was 49 microns from the pulpal surface, followed by the hypocalcified layer and the hypercalcified layer which were about the same width as before. The injected strontium had by now ceased to affect new dentin formation and the hypercalcified layer was succeeded by a normal amount of normally formed dentin and predentin. In succeeding stages (Fig. 3 and Fig. 1, *E*), no further changes were seen save that the affected zones moved away from the pulpal surface as incremental growth proceeded and the layer of normally formed and calcified dentin increased in thickness. After twenty-eight hours the hypercalcified layer remained practically constant in width in all sections examined up to eight days after the injection. This constancy in width shows that the strontium had acted for an equal length of time in all rats, namely, about twenty-four hours following the injection.

Silver Impregnation (Figs. 2, *B* and 3, *B*).—The hypocalcified layer stained very strongly with silver, almost as intensively as normal old predentin, indicating an arrest of the normal progress of dentin calcification. The fibrils were well visible. The hypercalcified layer stained less intensively with silver. No fibrils could be seen in this zone.

Timing of the Dentinal Changes.—In Fig. 4, the distance of the junction of the hypo- and hypercalcified layers from the pulpal surface (line *B* in Fig. 4) and of the calciotraumatic line from the pulpal surface (line *A* in Fig. 4) were plotted against the time of the experiment. Average lines drawn through these points are almost parallel. Line *B* runs through the origin, indicating that the junction between hypo- and hypercalcified lines corresponds to the time of strontium injection. The location of the intersection of Line *A* and abscissa to the left of the origin indicates that the matrix in which the calciotraumatic line develops had been laid down about twenty-four hours before the experiment began. Thus the hypocalcified layer was predentin laid down over a period of twenty-four hours before the start of the experiment.

DISCUSSION

The similarity of the calciotraumatic pattern produced by a various number of toxic agents leads one to believe in the identity of the response in all cases. This belief is strengthened by the resemblance in the timing of the different changes, since the analysis reported in this paper agrees essentially with that of Irving[10] after fluorine injections. In subsequent papers[19, 20, 21] it will be seen that this pattern has also been found in a series of other experiments.

Since the response of dentin to different experimental procedures is uniform, the term "calciotraumatic response" is suggested. The characteristic sequence of calciotraumatic line, hypocalcified layer, and hypercalcified layer can be termed "calciotraumatic band."

While the mechanism, especially the chemistry of the dentinal changes, is still obscure, their morphology can be analyzed. A brief summary of our present knowledge of the normal processes of dentin formation will facilitate the understanding of the pathologic changes.

Normal Formation and Calcification of Dentin.—In normal teeth the thin, argyrophil, subodontoblastic fibers grow under the influence of the odontoblasts to strong and corkscrew-shaped fibers (Korff's fibers), without, however, changing their chemical behavior and their argyrophilia (Fig. 5). The fibers of Korff, which are restricted to the depth of the odontoblast layer, seem to be homogenous and apparently do not consist of fibrils. The Korff's fibers of the pulp swell under the influence of the odontoblasts to form a collagenous and primarily homogenous matrix of predentin which is at first afibrillar (young predentin). This matrix differentiates secondarily into fibrils and cementing substance. Thus the young afibrillar predentin changes into the older fibrillar predentin (old predentin). The subsequent phase consists of calcification involving a simultaneous chemical change of the organic cementing substance and a precipitation of mineral salts (calcified dentin). The chemical change of the organic substance is tentatively explained as a "denaturing" of the proteins during the calcification of the matrix. This change of the cementing substance is responsible for the difference in stainability of fibrillar predentin

TABLE II
DENTINOGENESIS

	LAYER	CELLS	INTERCELLULAR OR GROUND SUBSTANCE	STAINING REACTION OF INTERCELLULAR SUBSTANCE	
				HEMATOXYLIN-EOSIN	SILVER
1.	Subodontoblastic layer	Fibroblasts	Thin branching afibrillar precollagenous fibers	Nonstaining	Black (argyrophilic)
2.	Odontoblastic layer	Odontoblasts	Strong, corkscrew-shaped, afibrillar precollagenous fibers of Korff	Nonstaining	Black (argyrophilic)
3.	Young (afibrillar) predentin	Odontoblastic processes	Afibrillar, homogeneous, collagenous, uncalcified predentin	Light pink or nonstaining	Dark brown
4.	Old (fibrillar) predentin	Odontoblastic processes	Differentiation into fibrils and cementing substance*	Dark pink (fibrils masked)	Fibrils dark brown. Cementing substance light brown
5.	Calcified dentin	Odontoblastic processes	"Denaturing" and calcification of cementing substance.* (Fibrils do not calcify)	Purple (fibrils masked)	Fibrils dark brown. Cementing substance unstained

*These stages are disturbed in the case of calciotraumatic response.

Figs. 2 and 3.—Photomicrographs of longitudinal sections of single upper incisors of rats given a single injection of strontium. Magnification ×850. The area is indicated in insert in Fig. 2*A*. *Od*, odontoblasts; *Pre*, predentin; *D*, normal calcified dentin; *C+*, hypercalcified dentin; *C–*, hypocalcified dentin; *EDL*, experimental dentin line; *CTL*, calciotraumatic line.

Figs. 2*A* and 3*A*, stained with hematoxylin-eosin; Figs. 2*B* and 3*B*, impregnated with silver.

Fig. 2(*A* and *B*). Rat 453*F*, twenty-eight hours after injection (see Fig. 1*C*). The hypocalcified layer (*C–*) is lightly stained with eosin in Fig. 2*A*, but stains darkly with silver (Fig. 2*B*). The hypercalcified layer (*C+*)stains dark with hematoxylin (Fig. 2*A*) but lightly with silver (Fig. 2*B*).

Fig. 3(*A* and *B*). Rat 456, four days after the injection. Hypocalcified and hypercalcified layers are unchanged. A thick layer of normal dentin and of predentin separate affected zones from pulp.

Fig. 2.

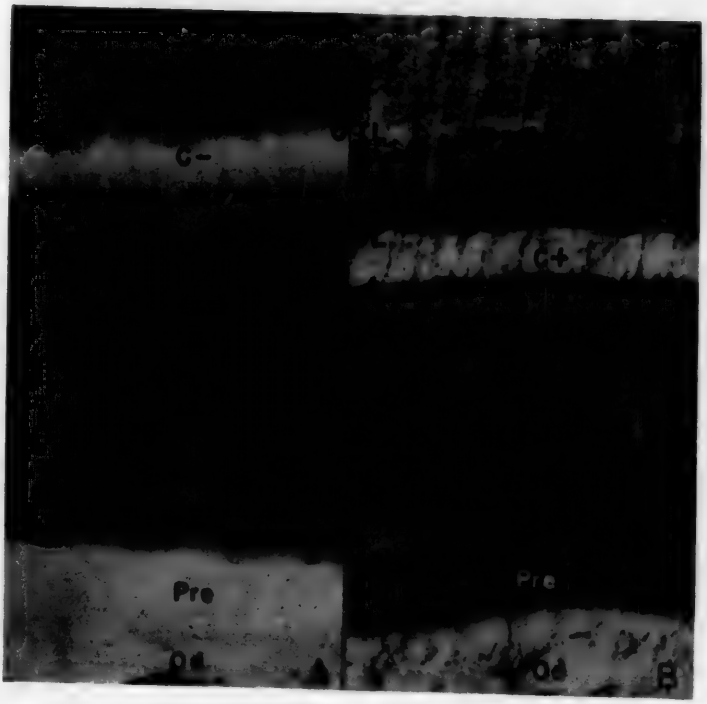

Fig. 3.
(See opposite page for legends.)

and calcified dentin. The cementing substance of the older predentin stains somewhat with silver while that of the dentin is argyrophobic. This sequence of events is diagrammatically indicated in Fig. 5 and summarized in Table II.

The Structural Changes in Calciotraumatic Response.—In the light of the preceding interpretation of the histogenesis of dentin, the structural aberration after strontium injection and more generally those of the calciotraumatic response, can be analyzed in the following manner:

The Hypocalcified Layer.—The hypocalcified layer shows essentially the staining reactions of late predentin, that is, after differentiation of fibrils in the intercellular matrix but before the change of the cementing substance characteristic for calcification. Therefore this hypocalcified layer can be considered as the pre-experimental predentin which did not calcify. The grenz-ray studies of Applebaum[9] after fluorine injection can be taken as supporting evidence because of the similarity of the calciotraumatic response to fluorine and strontium.

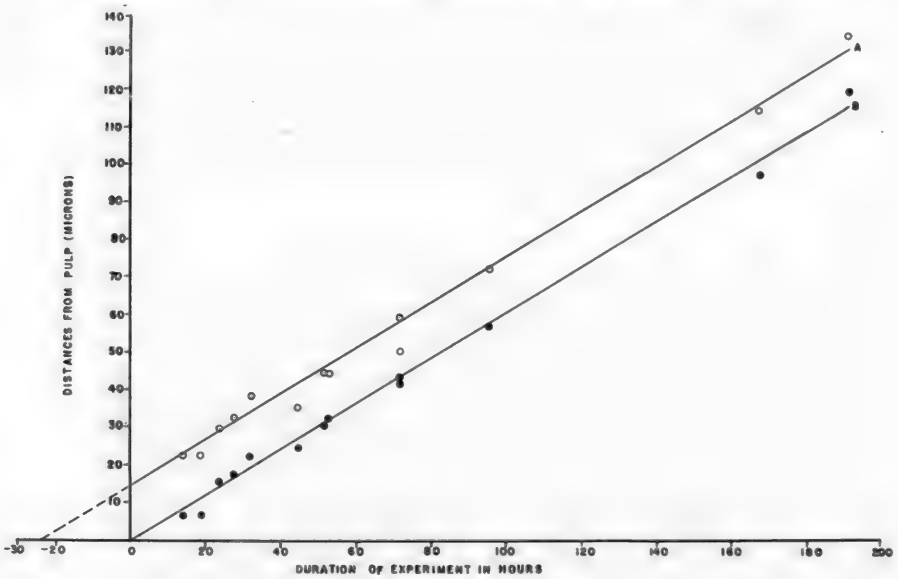

Fig. 4.—Distance in microns of experimental dentin line, ○, and of calciotraumatic line, ●, from pulpal surface were plotted against time in hours. By extrapolation line *A*, graph of the experimental dentin line, can be shown to intersect with origin of ordinates. Line *B*, graph of calciotraumatic line, intersects with abscissa at point corresponding fourteen hours before onset of the experiment.

Calciotraumatic Line.—The zone of hypocalcified dentin (pre-experimental predentin) is sharply demarcated from the normal dentin by the calciotraumatic line. Schour, Chandler, and Tweedy[6, 7] called particular attention to this phenomenon which they regarded as caused by a shock to calcium metabolism. This suggestion seems particularly apt, since the persistence of a layer of uncalcified predentin shows that calcium metabolism is severely disturbed for a period immediately following the formation of the calciotraumatic line.

Hypercalcified Layer.—By the method of silver impregnation, the matrix formed while the toxic agent is active has been shown to be deficient in fibrils.

As a result of incomplete differentiation, an excessive amount of calcifiable cementing substance persists. After calcification, more lime salts will be found per unit volume of this hypofibrillar dentin than in normal dentin. Thus the fundamental action of the toxic agent appears to be not only upon the processes of calcification, but also on those of matrix differentiation. This hypofibrillar intercellular substance calcifies completely soon after it is formed. At the fourteen and one-half hour stage this hypercalcified basophilic layer extends right up to the odontoblasts. The effect of the toxic agent lasts twenty-four hours so that after this time normal dentin formation is resumed.

The dentinal changes are interpreted as a result of direct or indirect damage to the odontoblasts. Irving[10, 24, 25] has produced evidence that, after injection of fluorine, the change of the calcium metabolism in the body as a whole is primary and the odontoblastic damage secondary. Whether this is true of all the procedures which cause the reactions described above can only be decided by future work, but it seems probable from general physiological principles.

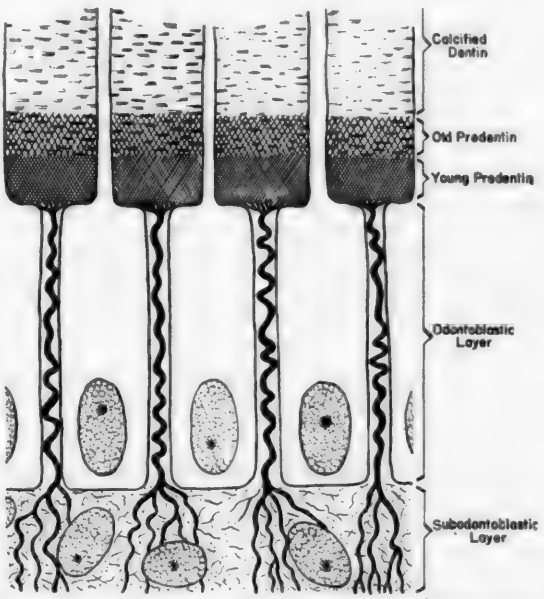

Fig. 5.—Diagrammatic representation of stages of normal dentinogenesis. Table II summarizes the structural details of the successive stages.

Timing of the Dentinal Changes After Strontium Injections.—The similarity in principle of the dentinal changes under various experimental conditions, the calciotraumatic response, and the regular topography of the different layers of the calciotraumatic band suggests also a discrete sequence in time. A practical application of the constancy in pattern suggests itself. If it could be shown that one of the boundaries between the several zones is also constant in time and not only in structure, a landmark could be produced at will for use as a point of reference for instance to measure dentinal growth and to time other changes in

the dentin. Two lines had to be considered for this purpose because they were sharply defined and of regular occurrence, namely, the calciotraumatic line and the junction between hypocalcified and hypercalcified dentin.

The calciotraumatic line, however, was found to be unsatisfactory because its development varied in time under different circumstances. It is formed at the pulpal boundary of calcified dentin and therefore is dependent in its position on the time when calcification ceases. Strontium injection stops calcification instantaneously, while calcification continues for about six hours after injection of fluorine.

The junction of hypocalcified pre-experimental dentin and the hypercalcified experimental dentin, which will be termed "the experimental dentin line," is more useful as a permanent mark in the dentin. It coincides with the exact time of experimental injury, because the production of normal predentin, especially its fibrilization, ceases immediately after the injection. It is suggested to use the injection of strontium for the production of the experimental dentin line because the calciotraumatic band after strontium injection is especially well marked.

Calciotraumatic Response of the Dentin.—The calciotraumatic response of the dentin to a specific injection consists of the following steps:

1. The predentin present at the time of the injection remains uncalcified.
2. The border between the predentin and calcified dentin becomes sharply delineated as a distinctly hematoxylin-stained calciotraumatic line.
3. The predentin forming immediately after the injection (beginning at the experimental line) becomes disturbed in formation and becomes hypercalcified. Specifically, the differentiation of fibrils is disturbed, with the result that there is an excessive amount of calcio-receptive cementing substance. This portion becomes, therefore, hypercalcified.

The above changes proceed as a rule for twenty-four hours.

4. After twenty-four hours the formation and calcification of the dentin becomes normal, but the injured zones (hypocalcified dentin, experimental dentin line, hypercalcified dentin) remain unchanged and serve as a permanent record.

SUMMARY AND CONCLUSIONS

The effect of single injections of strontium chloride on the dentin of the rat incisor has been studied histologically in sections stained with hematoxylin-eosin and impregnated with silver.

Strontium produced changes in the dentin of a definite pattern consisting of (a) a calciotraumatic line, (b) a hypocalcified layer, and (c) a hypercalcified layer of dentin.

Measurements showed that the hypocalcified layer represented the pre-experimental predentin which had remained uncalcified. The hypercalcified layer was formed immediately following the injection. The border between hypo- and hypercalcified layers of dentin represented the demarcation between pre-experimental and experimental dentin and is called the experimental dentin

line. Silver staining showed that the hypocalcified layer had a structure similar to that of old predentin, and that the hypercalcified layer, which was intensively stained by hematoxylin, contained fewer fibrils than the normal dentin.

It is suggested that these reactions be called the "calciotraumatic response" of the dentin, in view of the similarity of the dentinal picture after a number of different procedures. This response involves a disturbance in formation as well as in calcification of the dentin.

A single injection of strontium is an effective and accurate means of marking the dentino-pulpal border at the beginning of different experimental procedures.

The analysis of the structure of the layers of the calciotraumatic band was used to outline hypothetically the stages of dentinogenesis.

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GLYCOGEN AND CARBOHYDRATE—PROTEIN COMPLEX IN DEVELOPING TEETH OF THE RAT

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THIS report is a preliminary survey of the localization of glycogen and of carbohydrate-protein complexes in the developing teeth of the albino rat. The wide distribution of polysaccharides and particularly of mucopolysaccharides, mucoproteins, and of glycoproteins has been emphasized in the reviews by Meyer (1945, 1947) and by Stacey (1946). Recent work of Gersh and Catchpole has served to emphasize their vital roles.

The methods employed in this study are different than those which have been used by previous investigators. Fixation of the tissues was achieved by freezing and drying. This technic minimizes protein denaturation and displacement. Enzyme activity is inhibited, thus limiting post-mortem changes in the protoplasm. Diffusion of other intra- and extracellular components is prevented or reduced to a minimum. While undecalcified specimens have been studied in the past, such investigations have generally been made on celloidin-embedded material. In order to avoid prolonged treatment of the tissues with organic solvents such as ether and alcohol, we have utilized various waxes as embedding agents.

A new histochemical method for carbohydrate and carbohydrate complexes developed by Hotchkiss (1948) was employed. This, coupled with above-mentioned technical improvements, made possible more precise intra- and extracellular localization of these materials. The resulting findings may permit more rational interpretation of some aspects of the pathogenesis of dental caries.

Studies of glycogen distribution in developing teeth have appeared sporadically over the past fifty years. Creighton (1896) described glycogen in the enamel organ of the rodent incisor. Sundberg (1924) studying a 40 millimeter human embryo, reported glycogen granules in the early tooth germ but found that it did not occur in mature ameloblasts. The oral epithelium and all of the cells of the tooth germ, particularly those which differentiate to form ameloblasts, were shown to contain glycogen in Glock's study (1940). In later stages the material was not present in the ameloblasts, odontoblasts, or pulp. Horowitz (1942), in studies on human and rat fetal heads, noted glycogen in the dental lamina, dental sac, and along the "outer" edge of the ameloblasts. The most recent study, that of Bevelander and Johnson (1946) was made on pig embryos. They reported positive staining of the epithelium of the dental lamina. In the early bud stage, the cells of the stellate reticulum and the cells

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which were to become ameloblasts contained glycogen. In more advanced stages, just before formation of enamel and dentin, the material was demonstrated in the stellate reticulum and in the stratum intermedium. Glycogen disappeared when calcification began.

These cited studies were conducted on material which had been fixed with formalin or alcohol. The staining reactions employed included Best's Carmine, Bauer-Feulgen, and the Gage iodine method. A summary is contained in Table I.

In 1917, from a preliminary study of tooth protein, Gies and Noland reported the presence of a glycoprotein. Other kinds of protein have been described, as for example, the enamel protein which has been demonstrated by Bödecker and Gies (1924), Rosebury (1930), Chase (1935), Pincus (1936), Forshuvud (1944), Frisbie, Nuckolls, and Saunders (1944), Gottlieb (1947) and many others.

Rosebury (1930) isolated a protein material from enamel after removal of mineral elements with 1.5 per cent acetic acid. After testing the solubility in strong acids and alkalies and the response of this substance to proteolytic enzymes, he concluded that it had properties similar to keratin, of the neurokeratin group. The acid dialysate contained no biuret-positive material.

Pincus (1936) isolated protein material from enamel after dissolving intact enamel in 10 per cent acetic acid to remove the mineral. The remaining material gave a positive Millon's and negative nitroprusside reactions. Preliminary examination of the x-ray spectrograph indicated a pattern differing from keratin. He concluded that "the organic material appears to be a protein containing tyrosine and resembling reticulin." Later studies (1934), by the same investigator revealed solubilities which were not characteristic of keratin.

Nuckolls, Saunders, and Frisbie (1942), using Unna's staining method for the demonstration of eleidin, associated this protein with enamel matrix.

The protein matrix of dentin has been compared to that of bone and is said to consist primarily of collagen (Bevelander, 1941).

MATERIAL AND METHOD

Albino rats whose age ranged from 0 to 16 days post partum were used. The upper and lower jaws were dissected immediately, and the tissues were frozen and dried. This was accomplished by freezing the tissues in isopentane chilled in liquid air at −140 to −155° C. They were then dehydrated in vacuo at −32° C. The specimens were trimmed so that the molars and occasionally the incisors were included in the blocks. They were then embedded in either 62° to 65° C. paraffin or in the chloroform-extracted fraction of carnauba wax. The latter, because of its peculiar physical properties, was more suitable for the handling of the completely calcified stages. The infiltration was carried out in vacuo for fifteen to twenty minutes. The tissues were then embedded and sections were cut with a special hardened steel, bone-cutting knife at thicknesses varying from 4 to 10 microns.

TABLE I

SUMMARY OF LITERATURE ON GLYCOGEN DISTRIBUTION IN DEVELOPING TEETH

AUTHOR	ANIMAL	AGE	FIXATIVE	METHOD	ORAL EPITHELIUM DENTAL LAMINA	OUTER ENAMEL EPITHELIUM	STELLATE RETICULUM	STRATUM INTERMEDIUM	AMELOBLASTS	ODONTOBLASTS	PULP
Creighton (1896)	Rat Cat	Fetal		Iodine	+	+	+	+	+	–	–
Sundberg (1924)	Human	40 millimeter embryo	Absolute alcohol	Best	+*	+	+				
Harris (1932)	Rat				+			–			+
Glock (1940)	Rat Cat	3 days prepartum Fetal	Bouins	Carleton's modification of iodine and Langhans	+ +	+†	+†	–	–	–	–
Horowitz (1942)	Rat Human	Up to 1 day prepartum 22, 31, 33 millimeters embryos	95% alcohol	Gage, Best, Bauer-Feulgen	+ +	+	+	+	–	–	– –
Bevelander and Johnson (1946)	Pig	15 to 140 millimeter embryos	Carnoys	Decale 3% HNO_3 Gage Iodine	+	+‡	+‡	+‡	+§		–
Engel and Furata (this paper)	Rat Molar Incisor	0 to 16 days post partum	Freezing and drying	Periodic acid Fuchsin Sulfite	+ +	+	+	+** +**	–	–	–** +

*In Enamel Cord.
†Disappears several days after birth.
‡Disappears when calcification begins.
§Undifferentiated ameloblasts only.
**Present occasionally.

The sections were mounted on albuminized slides with finger pressure. It was found necessary to slightly prewarm the carnauba wax sections in order to avoid shattering. This latter material was then removed with chloroform; the paraffin was removed with xylol and chloroform.

Denaturation of the proteins was carried out before using the histochemical reagents. Since some of the proteins are soluble at the pH values of the various solutions used, precipitation and preliminary denaturation of these proteins to prevent their loss or shift was regarded as necessary. In addition, the denatured protein seems to be somewhat more reactive than the native form. The following agents were used: absolute alcohol, 5 per cent alcoholic mercuric chloride, saturated ammonium sulfate, and 50 per cent alcoholic formalin. Some of the tissues were passed directly to the staining reagents through graded alcohols without this preliminary denaturation.

A specific histochemical reaction for polysaccharides devised by Hotchkiss (1948) was used. This involves a preliminary oxidation with periodic acid in order to convert the hydroxyl groups in the 2 and 3 position to aldehydes. After reduction of the excess periodic acid, the Schiff reaction for aldehydes with leuco-fuchsin was utilized. Excess fuchsin was removed in a sulfurous acid wash and the polysaccharides were stained red. Malachite green, 25 mg. per cent, was used when counterstaining was desired.

Since carbohydrate may be present in the form of mono-, di-, or polysaccharide and may be part of a protein or lipoid complex, some technic for differentiating these was required. For this purpose a series of solubility reactions, specific for each of these groups, was employed. Glycolipids, if present, could be eliminated by extracting the section with methyl alcohol and chloroform at 50° C. overnight. The simple carbohydrates and uronic acid derivatives were removed by water. Free aldehyde groups are generally present in tissues in very insignificant quantities and were in any event removed by solution. Elimination of the periodic acid oxidation acted as a control for these. Glycogen was determined by noting the distribution of red-staining granules which were removed by incubating with saliva at 37° C.

OBSERVATIONS

Glycogen Identification

Molars: Glycogen deposits occur in the form of coarse, closely packed granules which are distributed throughout the cytoplasm of the cells of the Malpighian layer of the oral epithelium. The basal or germinal layer is entirely free of this material.

When the oral epithelium invaginates into the connective tissue to form the dental lamina, the glycogen distribution remains essentially unchanged; and the basal cells are glycogen free (Fig. 12). As the tooth bud becomes differentiated and the four layers of the enamel epithelium are formed, the glycogen is most concentrated in the form of large granules in the cytoplasm of the cells of the outer enamel epithelium and of the stellate reticulum (Fig. 14).

Glycogen was not found in the ameloblasts of the molars. Occasionally this material appeared in the form of small granules in the connective tissue

cells of the mesodermal pulp. It was noted to appear only sporadically and inconsistently in very minute quantities in the odontoblasts.

Incisors: The incisor shows a different distribution of glycogen. Large aggregates of coarse granules appear at the basal end of the odontoblasts in the region of dentin formation (Fig. 13). The mesenchymal pulp cells also contain abundant quantities in the form of small granules (Fig. 13). At the basal or formative end of the tooth, the cells of the odontogenic epithelium contain small granules which are also demonstrated in the ameloblasts in increasing quantity toward the middle third of the tooth. In this instance the glycogen appears primarily in the perinuclear area (Fig. 5). The quantity of glycogen in the odontoblasts and ameloblasts diminishes toward the incisal third of the tooth.

Glycoprotein Identification

Glycoprotein localization was comparable in incisors and molars. The cement substance between the epithelial cells of all of the layers of the enamel organ is shown to contain a glycoprotein. In addition, small quantities of glycoprotein can be demonstrated in the cells of the outer enamel epithelium, stellate reticulum, and in the stratum intermedium (Figs. 4 to 8). The cytoplasm of the ameloblasts is clear until the stage preliminary to enamel formation. At this time, and during the rest of the cytomorphosis of these cells, glycoprotein can be demonstrated in the infranuclear area of the cytoplasm. Changes in the aggregation of this material as the cell differentiates may be most clearly demonstrated in the incisor where the various stages of differentiation may be seen as one progresses from the basal end to the incisal edge (Figs. 5 to 8). In the young cells, the material appears almost optically homogeneous; as the cells grow older, aggregation increases until large granules are demonstrable at the incisal edge. This same progression is shown in the sequence from the early stages of molar development up until the later phases (approximately sixteen days). As the ameloblasts atrophy, preliminary to the formation of the enamel cuticle, the density of the glycoprotein material appears to increase. Occasionally the ameloblasts show a reticulation associated with fine granule formation. This is due to ice crystal artefacts.

In the very early stages of tooth formation, the basement membrane separating the cells of the oral epithelium from the underlying connective tissue consists in part of a delicate undulating glycoprotein membrane which has very fine radial projections into the connective tissue (Fig. 12). As the dental lamina proliferates and invaginates to form the tooth bud, this basement membrane is continuous with the membrana preformativa (Fig. 1).

The enamel matrix is difficult to demonstrate because of its solubility below pH values of 5 to 5.5. In order to prevent this loss, a number of technics were employed. Attempts to denature the protein to an insoluble form were made. Saturated ammonium sulfate, 5 per cent alcoholic mercuric chloride, absolute alcohol, methyl alcohol, and 50 per cent alcoholic formalin were used. Only the last was effective. In addition, the sections were covered with a very thin film of polystyrene which had been prepared as a 0.5 to 1 per cent solution in carbon tetrachloride. The film permitted diffusion of the reagents through

its pores, but the larger protein molecules were unable to leave the tissue. Upon removal of the sections from the acid reagents, these proteins were reprecipitated in situ. Rapid passage of the untreated sections through the sulfurous acid solution aided retention of the enamel protein, but the results were not consistent.

The structure of the matrix was difficult to determine because of the very slight differences in the refractive indices of its elements and because of the difficulty involved in preventing its solution despite denaturation. In some instances it appeared to have a structure of fine glycoprotein fibrils which were continuous with the basal end of the ameloblast (Fig. 11). In the sections where the denaturation was more complete, the structure appeared to show a homogeneous distribution of glycoprotein throughout the mass (Figs. 9 and 10). When the enamel matrix had been dissolved and then reprecipitated, all evidence of orientation was lost and a glycoprotein reticulum was noted.

The dentin contains ground substance and fibrillar structures but these cannot be readily demonstrated as discrete components because it appears that their refractive indices, when stained by the method employed, are very similar. The matrix material is initially demonstrated as an apparent thickening of the dentino-enamel junction associated with a differentiation of the adjacent pulp cells to columnar forms (Figs. 1 to 3). At this time the cytoplasm of these cells exhibits the presence of very fine glycoprotein granules. These fill the infranuclear portion of the cell. Occasionally, as in the case of the ameloblasts, the cytoplasm appears optically homogeneous.

The cells of the pulp constitute a mesenchymal syncytium. The anastomosing cells have red-staining processes which contain carbohydrate protein complexes or are coated by such complexes (Figs. 1 to 3).

DESCRIPTION OF FIGURES

A., ameloblasts; *B.M.*, basement membrane; *B.V.*, blood vessel; *C.*, cement substance; *C.T.*, connective tissue; *D.*, dentin; *E.*, enamel matrix; *E.S.*, enamel space; *G.*, glycogen; *Gp.*, glycoprotein; *N.*, nucleus; *O.*, odontoblasts; *O.E.*, outer enamel epithelium; *P.*, pulp; *Pf.*, membrana preformativa; *Pr.*, predentin; *R.Ep.*, reduced enamel epithelium; *S.I.*, stratum intermedium; *S.R.*, stellate reticulum.

Figs. 1 to 3 show characteristic stages in histogenesis of dentin in molar of 6-day-old animal. Initially, pulp is separated from ameloblasts by basement membrane; odontoblasts are undifferentiated. Columnar odontoblasts containing glycoprotein then appear, the membrana performativa thickens, and dentin formation is noted. (×1066.)

Fig. 1.—Undifferentiated odontoblasts from basal area.

Fig. 2.—Early dentin formation.

Fig. 3.—Fully differentiated odontoblasts.

Figs. 4 to 8 illustrate changes in aggregation of glycoprotein occurring in cytomorphosis of ameloblasts in incisor of 6-day-old animal. In odontogenic region, cells are almost free of material; they then contain finely dispersed glycoprotein; as cells become older, large granules of glycoprotein are noted in cytoplasm. Except for occasional remnants, enamel matrix is not seen since tissue was undenatured, and enamel glycoprotein was dissolved by periodic-fuchsin reagent. Glycogen localization is also demonstrated. (×1066.)

Fig. 4.—Ameloblasts from basal zone. Reticulation of cytoplasm is caused by ice crystal artefacts, nodal points of which cause granular appearance of cytoplasm. There is actually very little glycoprotein in cytoplasm. Note glycoprotein nature of cementing substance between cells.

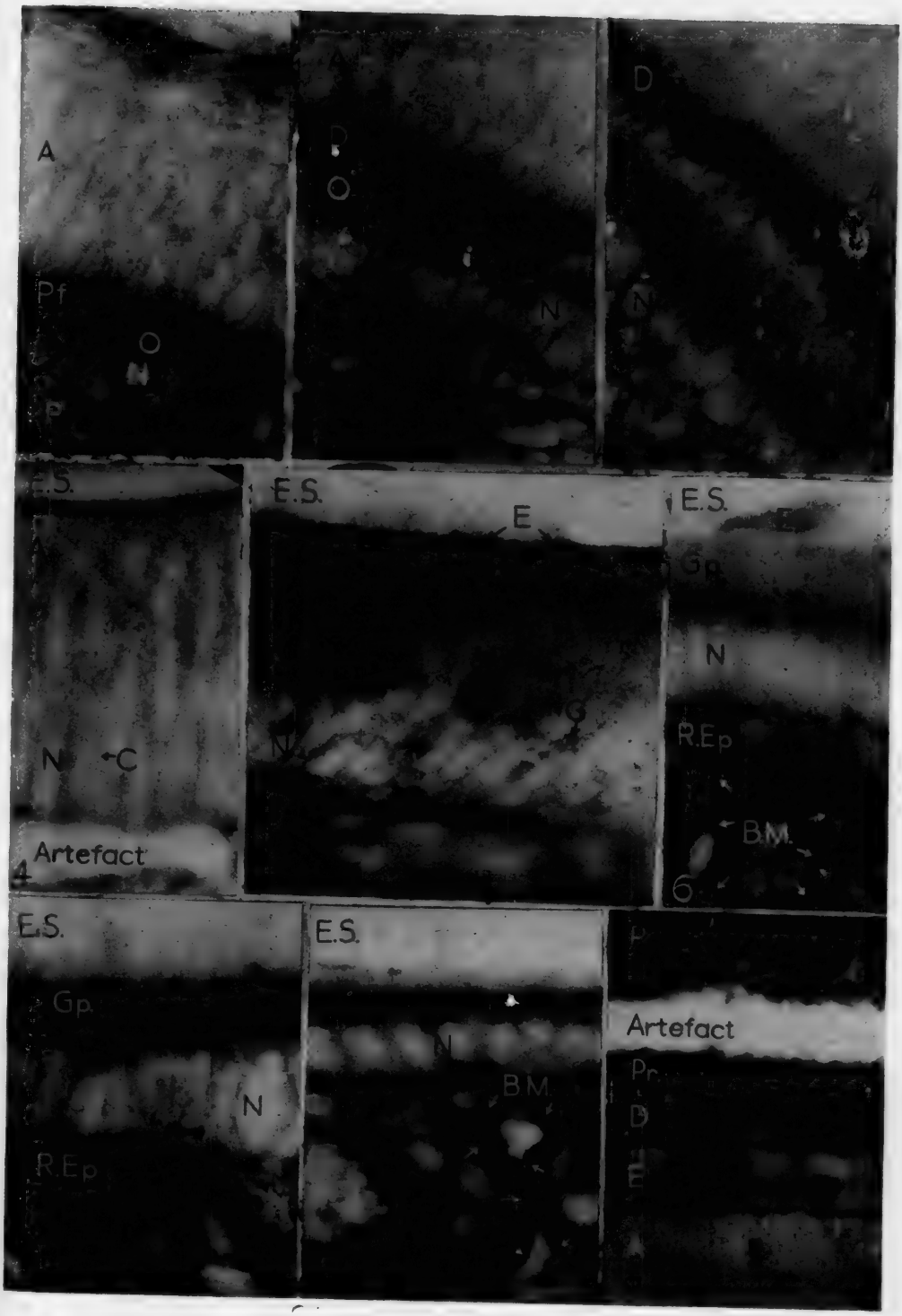
Fig. 5.—Ameloblasts from middle third. The large black perinuclear granules are glycogen. Remnants of enamel matrix are seen.

Fig. 6.—Cells from middle third. Note remnant of enamel matrix.

Fig. 7.—Cells from incisal third.

Fig. 8.—Cells near incisal tip.

Fig. 9.—Section from molar of 6-day-old animal. Preliminary denaturation with 50 per cent alcoholic formalin at 60° for forty-eight hours has made possible retention of enamel matrix. (×446.)



Figs. 1-9.

(See opposite page for legends.)

DISCUSSION

The somewhat conflicting findings of other investigators with reference to glycogen distribution may be attributed to several factors, namely: 1. Type of fixation employed. 2. Variation in staining methods. (The Bauer-Feulgen method has been the most reliable.) 3. Differences in glycogen distribution in different teeth, different species, or at different stages of development.

Our investigation serves to clarify somewhat the topographical localization of glycogen. The freezing and drying method prevents extracellular or intracellular diffusion of the glycogen; it is precipitated in situ. In addition, the enzymes which ordinarily might lead to glycogenolysis are immediately inhibited. Further shifts of this substance are minimized by avoiding prolonged use of decalcifying reagents and solvents associated with celloidin infiltration and embedding. The specificity of the histochemical method employed, coupled with the differentiating solubility reactions and the amylase (saliva) control, insured a more precise analysis.

Our knowledge at present does not permit formulation of definite correlations between the chronology or topography of the appearance of glycogen and its functional significance. Gutman and Gutman (1941) and Gutman, Warrick, and Gutman (1942), and others have emphasized the role of glycogen as a phosphate donor in calcification coupled with the action of phosphorylase and phosphatase. The latter enzyme has been localized in developing teeth in close proximity to areas shown to contain glycogen (Engel and Furuta, 1942). However, it is also evident from our material that calcification proceeds at stages where no glycogen can be demonstrated in the ameloblasts and odontoblasts.

Glycogenolysis is accompanied by the release of phosphate bond energy. Since this carbohydrate is found in areas of the tooth which are known to be growing very rapidly, it would seem possible that it may be associated with areas of high metabolic activity. It is possible that a differential between the activity of the incisor ameloblasts and odontoblasts and those of the molar accounts for the absence of glycogen from the latter. Proof for these postulates is, however, not now available.

Our findings serve to offer a rational explanation for the difficulties involved in retaining enamel matrix in decalcified specimens; they also explain

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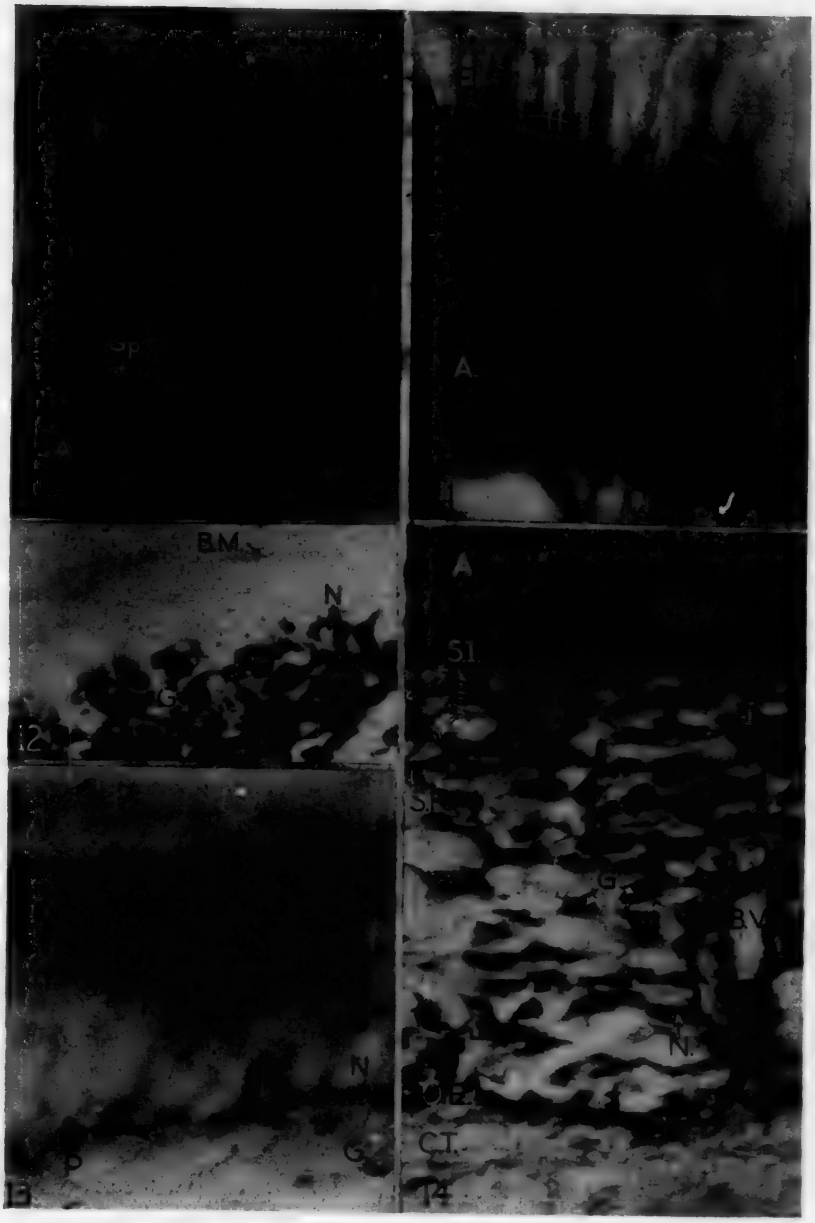
Fig. 10.—Enamel glycoprotein from cusp tip area of molar of 11-day-old animal. Section was denatured in 50 per cent alcoholic formalin. (×1280.)

Fig. 11.—Enamel glycoprotein from similar area as shown in Fig. 10. Tissue was not denatured but passed rapidly through sulfurous acid wash; some elements of the matrix were thus retained. (×1280.)

Fig. 12.—Glycogen distribution in dental lamina of term animal is shown in form of closely packed aggregates. Basal layer of cells is glycogen free. Glycoprotein containing basement membrane of oral epithelium is also shown. (×536.)

Fig. 13.—Large aggregates of glycogen in terminal part of odontoblasts and in pulp of incisor of term animal are demonstrated. (×1280.)

Fig. 14.—Distribution of glycogen in layers of enamel epithelium is noted in form of dark granules. Note relatively large quantities in stellate reticulum. Glycoprotein basement membrane of blood vessel in stellate reticulum is also shown. Molar of 9-day-old animal. (×536.)



Figs. 10-14.

(See opposite page for legends.)

the basis for the success of the technics employed by Bödecker (1905), Malleson (1924), Beckwith and Williams (1927), Arnim (1935), Frisbie, Nuckolls, and Saunders (1944) and others. These writers recognized the fact that the acid used to decalcify dental tissues caused dissolution of the matrix of the enamel unless special precautions were taken in embedding. This was attributed by some to the solution of the calcium salts leading to a mechanical dissolution of the matrix material. Other investigators, notably, Frisbie, Nuckolls, and Saunders (1944), called attention to the action of strong acid on the protein. They recognized the denaturing action of the formalin when this fixative is maintained at alkaline pH and the tissue is retained in the solution for long periods. They succeeded in recovering matrix material from fully calcified teeth using this method. Prolonged fixation of such a fully calcified structure as enamel is essential because the rate of diffusion of the fixative through the dense mineral structure is extremely slow. The failure of others to duplicate these results may be explained in part by shorter periods of fixation. The acid-soluble protein is not denatured and consequently is dissolved by subsequent treatment. Weinmann, Wessinger, and Reed (1942), in a combined chemical and histologic study, reported decreased per cent of organic material and water and increase in the organic portion of the enamel as one approached the cuspal areas where the enamel is said to be more "mature." Because the histologic sections showed the absence of material in the areas of relatively high mineral and relatively low protein content, it was concluded that there must be a removal of protein as the enamel differentiates.

It is not necessary to invoke this concept if one considers that the matrix was retained in the less calcified areas because of the relative ease of denaturation while it disappeared from the cuspal area where the penetration of the denaturing agent was limited. It is quite possible that the change in the values obtained was primarily reduction of the protein concentration by influx of minerals and loss of water with no change in the total amount of protein. Our observation would also obviate the necessity of attributing a catheptic enzyme activity to the ameloblasts.

Rosebury (1930), and Pincus (1936, 1939), using chemical methods, have isolated a protein from enamel after removal of the mineral in acid solution. Rosebury, however, was unable to demonstrate protein in the acid dialysate or in the acid in the collodion bag. This may be explained by one of four possible considerations, namely: 1. Species or age difference, or both. 2. Hydrolysis of the acid soluble protein by the acid used. 3. Since nitrogen determinations on the acid solutions were not made, the absence of protein cannot be considered to have been completely demonstrated; or 4. Minute amounts of protein not detectable by the biuret reagent may have been present. It is noteworthy that Rosebury reported that upon ashing dry enamel the loss was over 4 per cent; of this only approximately 0.3 to 0.5 per cent was identified as the acid insoluble protein. It is possible that a significant proportion of the remaining 3.5 per cent may have been the acid-soluble protein which we have described here.

Recently Gottlieb (1947) and Frisbie, Nuckolls, and Saunders (1944) have emphasized the enamel protein in discussing the pathogenesis of caries. The production of proteolytic enzymes by certain of the oral bacteria has been postulated to explain preliminary dissolution of the protein. However, the preponderance of evidence indicates that such a mechanism may not be the primary one involved.

Stephan (1937) has demonstrated a local drop of pH to levels ranging from 4.7 to 7 on plaques of teeth in caries-susceptible mouths. There is a large mass of evidence favoring acceptance of the *Lactobacillus acidophilus* as the major pathogen responsible for enamel caries. This is an aciduric and acidogenic organism. On the basis of the evidence presented in this report, it appears entirely possible that acid elaboration on the tooth surface will cause solution of the protein of the enamel. This may well be responsible in part for the lesion of caries.

The relationship of the glycoprotein material found in the ameloblasts and odontoblasts to enamel and dentin matrix materials which are also protein-carbohydrate complexes is being investigated.

SUMMARY

1. Glycogen was found to occur in the Malpighian layer of the oral epithelium, in the dental lamina, and at varying times in the outer enamel epithelium, stellate reticulum, and stratum intermedium of the developing rat tooth. The ameloblasts and odontoblasts and pulp of the incisor contained this substance in the early stages. In a few instances, glycogen was found in the odontoblasts and pulp of the molar.

2. The cement substances between the ameloblasts contains a glycoprotein.

3. Glycoprotein material was observed in the cells of the outer enamel epithelium, stellate reticulum, stratum intermedium, and in the processes of the connective tissue pulp cells.

4. Glycoprotein granules were observed to appear in the cytoplasm of the odontoblasts and the ameloblasts in the stages preliminary to the formation of dentin and enamel.

5. The dentin was shown to contain a carbohydrate-protein complex.

6. The demonstration of an acid-soluble carbohydrate-protein complex as one of the components of developing enamel matrix is regarded as particularly significant for the understanding of the pathogenesis of dental caries.

I am indebted to Dr. Granville A. Bennett for extending the courtesies of his laboratories and to Dr. Isidore Gersh for his counsel.

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A COMPARISON OF TWO METHODS OF ASHING ENAMEL AND DENTIN*

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ALTHOUGH numerous analyses of human teeth have been made, it is nearly impossible to compare the analyses made by different workers. There are several reasons for this difficulty. First, *the material studied varies considerably;* some workers examined whole teeth, some separated the enamel from the dentin, others have cut the tooth into two parts, crown and root. These preparations are not identical in chemical composition so that different combinations have given different results. Second, *different ashing procedures are used.* Some workers do not ash the samples before determining inorganic constituents. Others use one of two customary ashing methods: (1) removal of organic matter by an alkaline organic solvent or (2) removal of organic material by an incineration process. The organic solvent removes mostly organic matter, whereas incineration drives off carbonate in addition. The choice of ashing method therefore affects the percentages of inorganic constituents calculated on the basis of ash weight. Third, *organic and inorganic constituents are calculated on different bases,* namely, as percentages of wet, dry, or ashed weights.

The present study has been directed at the second problem listed above, that is, the differences which depend on the use of different ashing technics. Armstrong and Brekhus[1] have compared unashed and ashed samples. In this report a comparison is made of samples ashed by two common methods. Comparable aliquots of the same samples were ashed, respectively, by incineration and by solution in an alkaline organic solvent (KOH in ethylene glycol). Gabriel[2] made a similar study on ox-teeth samples ashed by heat and by extraction with potassium hydroxide in glycerol.† In the present paper, inorganic constituents were determined in both of the ashed residues.

EXPERIMENTAL METHODS

About fifty teeth, some caries-free and some with small cavities were obtained from the extraction clinic of the Strong Memorial Hospital. Carious material and adhering soft tissue were removed from the teeth with a dental burr. The teeth were dried overnight at 105° Centigrade. Each tooth was ground in a diamond mortar so that the powder would pass through a 60-mesh screen. Enamel and dentin were separated by the centrifugation-flotation process of Manly and Hodge.[3]

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*The data of this paper are taken from the thesis submitted by Mary Jane Bird for the degree Master of Science in the Department of Biochemistry and Pharmacology, School of Medicine and Dentistry, The University of Rochester, Rochester 7, N. Y.

†Burns and Henderson (*Biochem. J.* 29: 2385, 1935) pointed out that glycerol ash is not accurately representative of the original bone. In all cases, some phosphate was lost.

One aliquot of each enamel and of each dentin sample was ashed by Deakins' modification[4] of the Pregl microincineration process. A dentin sample of approximately 14 mg. was weighed into a small platinum boat, then placed in the outer portion of a micro-muffle furnace until charred. The boat was then pushed into the hottest part of hte furnace where the temperature was maintained at approximately 500° Centigrade. After ten minutes, the sample was removed and a microdrop of concentrated nitric acid was added to the cooled ash. The sample was slowly returned to the ignition chamber where it remained for ten minutes, or until it was pure white. The ash, after removal from the furnace, was cooled in a desiccator and weighed.

A similar procedure was followed for enamel. Eleven milligrams were weighed into a platinum boat. The dry-ashing procedure was omitted, and nitric acid was added to the unashed sample which was then heated fifteen minutes. This incineration will be referred to throughout the paper as the heat-ash method.

A second aliquot of each sample was ashed by the method of Crowell, Hodge, and Line.[5] Tooth tissue samples, ranging in weight from 30 to 260 mg. of enamel and from 240 to 1,400 mg. of dentin were placed in 50 c.c. centrifuge tubes. About 20 to 25 ml. of a solution of 3 per cent potassium hydroxide in ethylene glycol were added to the tooth substance. The centrifuge tube was placed above a heating unit so that the ethylene glycol boiled gently (±205° C.) until the organic matter was removed (usually ninety minutes). After the organic matter had been extracted, the glycol was removed by a series of centrifugations and washings with boiling distilled water. This method of isolating inorganic matter will be referred to as the glycol-ash method. In both cases, the residue is called the "inorganic content" of the tissue, the loss is called the "organic content"; the amounts and the materials thus described are different depending on the ashing method employed.

The heat-ashed in toto and 20 mg. aliquots of the glycol-ashed samples were dissolved in 3N hydrochloric acid and diluted with distilled water. From each solution an aliquot containing approximately 0.15 mg. of phosphorus was removed and the phosphorus was determined in ten samples by the colorimetric method of Berenblum and Chain,[6] in the remaining samples, phosphorus by the gravimetric Holtz procedure.[7] Other aliquots were taken for calcium and magnesium determinations. Each specimen contained about one milligram of calcium. A modification of the Katzman and Jacobi process[8] was used, titrating the oxalate against 0.05N ceric sulfate according to LeFevre and Nicholson[9] with an orthophenanthroline indicator.

The supernatant fluid from the calcium precipitation was used for magnesium estimation. The samples contained between 0.0 and 0.08 mg. of magnesium. A known quantity of magnesium was added to each aliquot to bring the total amount into the range of more accurate determination. The addition was made from a standard solution of $MgHPO_4 \cdot 3H_2O$; each sample received 0.130 mg. of magnesium. The method of Greenberg, Anderson, and Tufts[10] based on the procedure of Greenberg and Mackey[11] was employed in which magnesium was precipitated with 8-hydroxyquinoline. The precipitate was brominated and the excess bromide was measured by a thiosulfate titration. The ad-

dition of a known amount of magnesium solution apparently increases the error of the magnesium percentage calculations, since the small value remaining after subtracting the "blank" value contains all errors in the total determination, but the quantity of magnesium available in tooth samples is so small that this addition was necessary in order to achieve any degree of quantitative recovery. Since the same method of magnesium determination is used for both heat- and glycol-ashed tooth samples, the errors are comparable in these two series.

RESULTS

Organic Matter.—In Table I, the average organic and inorganic contents for each tooth type are listed. Inorganic content is calculated directly from the ashed and unashed weights while the organic content is computed by differences. The percentages of organic and inorganic matter in heat-ashed enamel are listed in the columns labeled "Heat"; percentages of organic and inorganic matter in glycol-ashed enamel are in the column marked "Glycol." In the column marked "Heat-Glycol" are recorded the averages of the differences between corresponding heat and glycol samples. All the heat-glycol differences for organic matter are positive. This would be expected by definition of the methods employed, since the glycol-ashing method removed the organic matter from the tooth samples, whereas the heat method also removed the carbonate. The over-all average "organic matter" for heat-ashed enamel (5.8 per cent) is appreciably greater than that (3.9 per cent) for glycol-ashed enamel samples. Fig. 1 shows the frequency distributions of the organic percentages. The central tendency for the heat-ashed enamel is to the right, that is, toward higher values.

TABLE I
INORGANIC AND ORGANIC MATTER IN ENAMEL AND DENTIN AS MEASURED BY HEAT- AND GLYCOL-ASHING PROCEDURES
(Expressed as per cent dry weight)

		ENAMEL					DENTIN				
	NUMBER ANALYZED	INORGANIC		ORGANIC		HEAT-GLYCOL	INORGANIC		ORGANIC		HEAT-GLYCOL
TYPE		HEAT	GLYCOL	HEAT	GLYCOL		HEAT	GLYCOL	HEAT	GLYCOL	
1	7	94.4	96.5	5.6	3.5	2.1	68.4	69.4	31.6	30.5	0.2
2	4	93.4	95.8	6.6	4.2	2.4	67.2	66.8	32.8	33.2	–0.4
3	8	94.2	95.8	.58	4.2	1.2	69.1	70.8	30.9	29.2	1.7
4	6	94.3	96.8	5.7	3.4	2.3	71.6	71.6	28.4	28.4	0.0
5	5	94.3	96.6	5.7	3.4	2.4	69.8	69.1	30.2	30.9	–0.7
6	4	94.8	96.9	5.2	3.1	2.1	69.2	72.3	30.8	27.7	3.1
7	4	94.2	96.0	5.8	4.0	1.8	69.5	68.2	30.5	31.8	–0.6
8	10	94 0	95 7	6 0	4 3	1 6	69 8	70 4	30 2	29 6	0.7
Average		93.8	95.3	6.2	4.7	2.0	69.4	69.0	30 6	30 9	–0.6
Standard deviation		0.8	1.6	0.8	1.6	1.7	1.9	3.5	1.9	3.5	2.4

The heat-glycol differences for the dentin samples are not as large and not as consistent as was the case with enamel. The average (30.6 per cent) for "organic" percentage by heat ashing is slightly lower than that (30.9 per cent) for glycol-ashed samples. The frequency distribution in Fig. 2 presents a curve for glycol-ashed dentin samples slightly to the left of the curve for heat-ashed samples. It is not known why clearly separated curves for "organic" percentages of heat- and glycol-ashed dentin were not obtained.

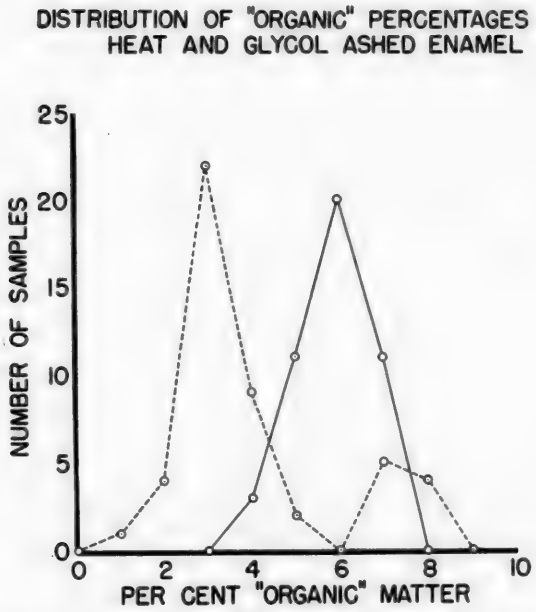

Fig. 1.—*Organic content of enamel.* Heat ashing drives off CO_2 in addition to organic matter so that the per cent loss (solid line) is greater than in glycol extraction (dotted line).

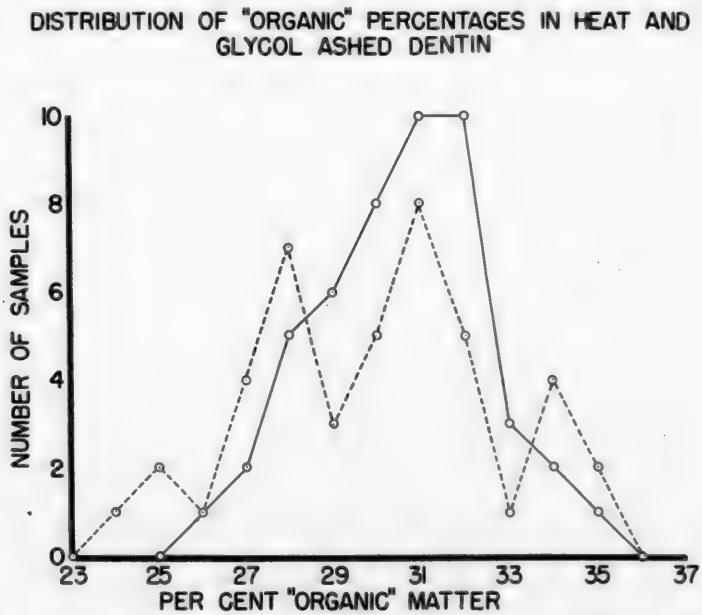

Fig. 2.—*Organic content of dentin.* The curve for the heat-ashed samples (solid line) is to the right of the curve for glycol-ashed samples (dotted line). The two curves are less clearly separated than were the curves for enamel.

Inorganic Constituents.—Table II shows little evidence of a difference between the calcium percentages in enamel from different tooth types. On the other hand there was a difference between the averages for heat-ashed enamel (38.2 per cent) and glycol-ashed enamel (37.2 per cent calcium). The individual calcium percentages of both heat- and glycol-ashed enamel fall in the same range.

TABLE II
CALCIUM, MAGNESIUM, AND PHOSPHORUS IN HEAT- AND GLYCOL-ASHED ENAMEL SAMPLES
(Expressed as per cent ashed weight)

TOOTH POSITION	CALCIUM			MAGNESIUM			PHOSPHORUS		
	HEAT	GLYCOL	HEAT-GLYCOL	HEAT	GLYCOL	HEAT-GLYCOL	HEAT	GLYCOL	HEAT-GLYCOL
1	37.0	36.6	0.4	0.69	0.62	0.07	18.5	17.8	0.7
2	37.9	38.0	0.0	0.93	0.74	0.19	18.2	18.2	0.2
3	38.9	36.8	2.0	0.80	0.62	0.18	18.3	18.1	0.2
4	39.1	38.1	1.2	0.72	0.68	0.04	18.8	18.0	0.8
5	37.2	36.0	1.1	0.84	0.68	0.16	19.2	17.7	1.5
6	38.6	36.2	2.4	1.39	0.67	1.23	18.9	18.1	0.8
7	38.2	40.4	−2.2	0.80	0.88	−0.08	18.8	19.3	−0.5
8	38.7	39.1	−3.8	0.80	0.64	0.14	19.1	19.2	0.0
Average	38.2	37.6	0.6	0.80	0.67	0.13	18.7	18.4	0.4

In the dentin, the percentages of calcium (Table III) are considerably higher in heat- than in glycol-ashed samples. There are no significant differences when the values are compared for the different morphological tooth types. For all tooth locations the heat-glycol differences are positive, with average values of 38.0 per cent calcium for heat- and 35.5 per cent calcium for glycol-ashed dentin. Fig. 3 shows the difference graphically, the two dentin-calcium curves run almost parallel courses but that curve for heat-ashed samples is far to the right of that of the glycol-ashed samples.

TABLE III
CALCIUM, MAGNESIUM, AND PHOSPHORUS IN HEAT- AND GLYCOL-ASHED DENTIN SAMPLES
(Expressed as per cent ashed weight)

TOOTH POSITION	CALCIUM			MAGNESIUM			PHOSPHORUS		
	HEAT	GLYCOL	HEAT-GLYCOL	HEAT	GLYCOL	HEAT-GLYCOL	HEAT	GLYCOL	HEAT-GLYCOL
1	36.7	34.4	2.2	1.60	1.58	0.02	17.8	16.5	1.5
2	38.9	36.2	2.9	1.87	1.50	0.40	20.9	17.1	3.8
3	38.5	34.8	3.7	1.82	1.52	0.30	18.4	17.1	1.4
4	36.6	35.8	0.7	1.38	1.28	0.10	17.9	16.2	1.5
5	38.8	35.5	2.9	1.11	1.59	−0.48	19.4	16.5	2.9
6	38.3	35.5	3.0	1.13	1.37	−0.24	19.2	15.5	3.7
7	38.3	36.5	1.8	1.38	1.37	0.04	19.1	15.6	3.5
8	38.4	36.0	2.5	1.56	1.08	0.49	19.4	17.4	2.0
Average	38.0	35.5	2.5	1.51	1.39	0.12	18.9	16.7	2.3

The picture of enamel magnesium is similar to that of enamel calcium. Table II gives positive heat-glycol differences except for second molars. The difference between the averages for micro-ashed enamel (0.80 per cent Mg) and for glycol-ashed enamel (0.67 per cent) is insignificant because of the error in the method.

The dentin magnesium heat-glycol differences in Table III are less positive than those of enamel. These differences vary widely and the values range from

0.49 per cent for third molars to –0.48 per cent for second premolars. The average heat-glycol difference is positive, however, as may be seen from the averages for heat-ashed (1.49 per cent Mg) and for glycol-ashed (1.39 per cent) dentin.

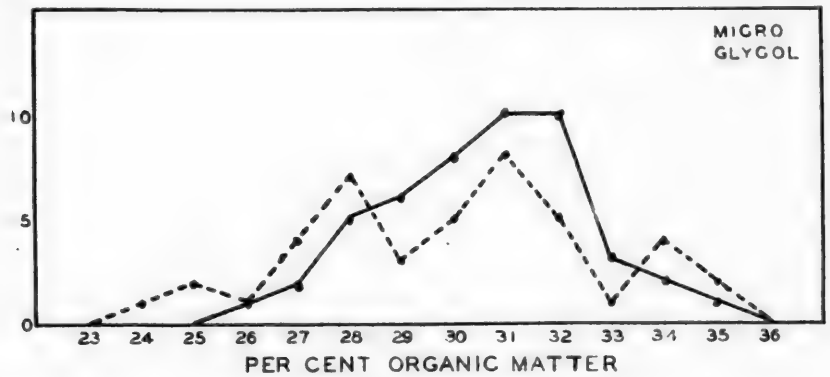

Fig. 3.

Phosphorus in enamel (Table II) follows a pattern similar to that of calcium. The heat-glycol differences are positive except for second and third molars, but in these the negative differences are small. It will be noted that the same tooth types also have negative heat-glycol differences for calcium. The average for heat-ashed enamel (18.7 per cent) is slightly greater than that for glycol-ashed (18.4 per cent) enamel.

The phosphorus analyses of dentin exhibit positive heat-glycol differences for all tooth types; there is no apparent dependence on type. The averages for heat-ashed (18.9 per cent phosphorus) and for glycol-ashed (16.7 per cent phosphorus) dentin differ appreciably. Fig. 4 presents two parallel curves with that of heat-ashed samples far to the right of that for glycol-ashed.

Further information concerning the comparison of the two ashing methods may be gained by studying the calcium/magnesium and calcium/phosphorus ratios. Having found that there is a variation in the percentages of the elements, the question may be raised, do their ratios remain constant when the samples have been ashed by different methods?

TABLE IV

CALCIUM/MAGNESIUM AND CALCIUM/PHOSPHORUS RATIOS OF HEAT- AND GLYCOL-ASHED ENAMEL

TOOTH POSITION	CALCIUM/MAGNESIUM			CALCIUM/PHOSPHORUS		
	HEAT	GLYCOL	HEAT-GLYCOL	HEAT	GLYCOL	HEAT-GLYCOL
1	65.0	76.3	–11.2	2.01	2.16	–0.12
2	51.2	56.2	–5.0	2.10	2.19	–0.03
3	66.1	60.4	9.5	2.10	2.09	0.01
4	69.7	62.4	–13.6	2.11	2.14	–0.01
5	46.0	72.0	–26.0	1.94	2.00	–0.04
6	27.9	45.7	–17.8	2.03	2.00	0.05
7	57.1	46.0	11.1	2.04	2.10	–0.06
8	58.0	64.6	–4.1	2.02	2.05	–0.05
Average	59.2	85.3	–32.3	2.05	2.06	0.00

Calcium and magnesium ratios of the enamel samples are given in Table IV. There is no correlation between calcium/magnesium ratios and tooth types. The average calcium/magnesium ratio for heat-ashed enamel is 59.2, for glycol-ashed

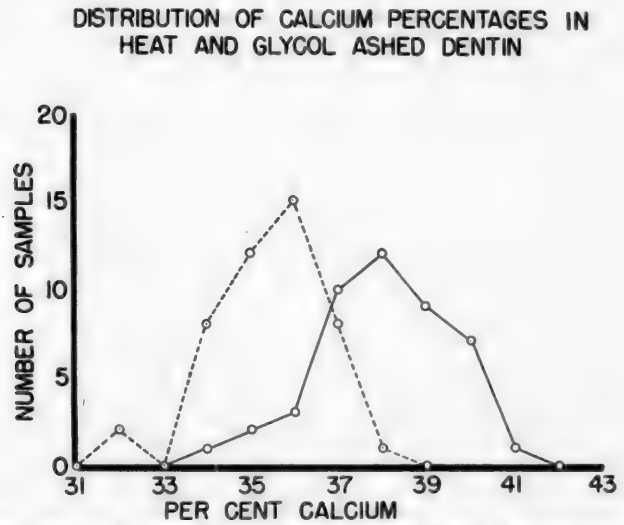

Fig. 4.—*Calcium content of dentin.* The calcium percentages in the heat-ashed samples are usually higher (solid line) than in glycol-extracted dentin (dotted line).

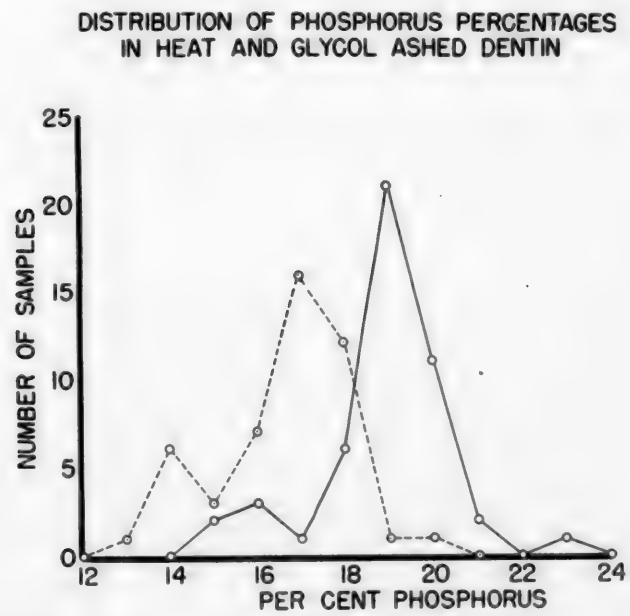

Fig. 5.—*Phosphorous content of dentin.* The phosphorous percentages are higher in dentin samples ashed by heat (solid line) than in samples ashed in glycol (dotted line).

enamel is 62.7. The average heat-glycol difference is negative (–5.3), but not appreciably so when one considers the great variation of the values involved. The discrepancy between the average difference and difference of the averages is explained by the fact that the former is the average of the heat-glycol differences of individual determinations.

Individual dentin calcium/magnesium ratio (Table V) vary (from 13 to 50) less than those of enamel. The average heat-glycol difference probably does not differ significantly from zero. The question of the constancy of the calcium/magnesium ratios may now be answered: the values are most irregular. In spite of the lack of constancy, however, the calcium/magnesium ratio differences, when heat- and glycol-ash values are compared, vary equally on either side of zero, indicating that the ashing processes do not markedly change the relation of magnesium to calcium.

TABLE V
CALCIUM/MAGNESIUM AND CALCIUM/PHOSPHORUS RATIOS OF HEAT- AND GLYCOL-ASHED DENTIN

	CALCIUM/MAGNESIUM			CALCIUM/PHOSPHORUS		
POSITION	HEAT	GLYCOL	HEAT-GLYCOL	HEAT	GLYCOL	HEAT-GLYCOL
1	23.4	22.4	1.0	2.06	2.10	–0.06
2	21.7	21.5	0.1	1.91	2.12	–0.20
3	21.9	23.5	–1.6	2.03	2.04	0.01
4	27.2	30.1	–2.9	2.00	2.22	–0.17
5	33.0	24.0	7.9	2.01	2.25	–0.25
6	35.6	26.1	9.6	2.00	2.16	–0.17
7	29.7	28.6	1.0	2.01	2.37	–0.36
8	25.9	31.3	–1.4	1.98	2.08	–0.10
Average	27.3	28.1	–0.4	2.03	2.15	–0.13

Calcium/phosphorus ratios (12 to 15) may also be considered to determine whether calcium and phosphorus percentages are proportionately lower for glycol than for heat ashing. If the changes are not identical, can any explanation of the discrepancies be offered?

DISCUSSION

Extractables in Glycol-ashing.—To assist in the comparison of the effects of ashing by the two methods, a table has been prepared of the average compositions of heat-ashed and glycol-ashed enamel and dentin samples (Table VI). From this table an answer may be found to the question, how much of each tissue is lost in the ashing procedure? The heat ash of enamel is 94 per cent of the dry weight, and since enamel is known to contain about 3 per cent of CO_2, the 6 per cent loss may be roughly attributed to the CO_2 plus 3 per cent of volatile matter, referred to as "organic matter." The glycol ash of enamel (See Column 2 of Table VI) constitutes about 96 per cent of the dry weight. Since the glycol ash contains all of the CO_2, the 4 per cent loss on glycol ashing contains the 3 per cent of "organic matter" volatilized by heating and in addition 1 per cent of extractables of unknown nature.

TABLE VI
COMPARISON OF ORGANIC AND INORGANIC CONSTITUENTS IN HEAT- AND GLYCOL-ASHED ENAMEL AND DENTIN SAMPLES

	ENAMEL			DENTIN		
	HEAT	GLYCOL	HEAT-GLYCOL	HEAT	GLYCOL	HEAT-GLYCOL
Organic*	5.8	3.9	1.9	30.6	30.0	0.6
Inorganic*	94.2	96.1	–1.9	69.4	70.0	–0.6
Calcium†	38.2	37.6	0.6	38.0	35.5	2.5
Magnesium†	0.8	0.67	0.13	1.49	1.39	0.10
Phosphorus†	18.7	18.4	0.4	18.9	16.7	2.2
Ca/Mg	59.2	85.3	–32.3	27.3	28.1	–0.4
Ca/P	2.05	2.06	0.0	2.03	2.15	–0.13

*Per cent dry weight.
†Per cent ashed weight.

In the case of dentin, the heat ash (Column 4, Table VI) is 69 per cent of the dry weight. Since dentin also contains about 3 per cent of CO_2, the balance, that is, the 28 per cent volatile matter, may be described as "organic matter." The glycol ash is 70 per cent of the dry weight, and since this ash contains the CO_2, there must have been 28 per cent "organic matter" extracted plus about 2 per cent of some unknown constituents. Generalizations based on such slight evidence are unwarranted however, the additional loss on glycol ashing may be simply explained as a solution of readily mobilized inorganic salts. The slightly larger loss from dentin might be ascribed to the lower density of dentin, and the consequent greater ease of diffusion of the alkaline glycol.

Compositions of Enamel Heat Ash and Glycol Ash.—The composition of enamel heat ash may be simply stated as follows: about 38 per cent calcium, just less than 1 per cent magnesium, and somewhat more than 18 per cent phosphorus, with enough oxygen and trace elements to make up the balance. If this heat ash were mixed with 3 per cent CO_2, there would be a reduction in the percentages of the principal components.

	Enamel Composition			
Ash	*Ca*	*Mg*	*P*	*Ca/P*
Heat	38.2	0.80	18.7	2.04
Heat if 3 per cent CO_2 were added	37.1	0.78	18.2	2.04
Glycol	37.6	0.67	18.4	2.04

From the last table it is apparent that the calculated percentages for calcium and phosphorus in the assumed mixture are very close to the actual values obtained in glycol ashing which presumably retains all the CO_2. The differences in each case are within the experimental error of the methods used. It may therefore be concluded that the principal differences between heat ash and glycol ash of enamel are (1) the 1 per cent unknown material extracted by alkaline glycol and (2) the absence of CO_2 in the heat ash.

Composition of Dentin Heat Ash and Glycol Ash.—When a similar calculation is carried out for dentin, the following data are found.

	Dentin Composition			
Ash	*Ca*	*Mg*	*P*	*Ca/P*
Heat	38.0	1.49	18.9	2.01
Heat if 3 per cent CO_2 were added	36.9	1.45	18.3	2.01
Glycol	35.5	1.39	16.7	2.13

The calculated values for a mixture of heat ash plus 3 per cent CO_2 do not compare favorably with the experimentally determined values for the glycol ash; in each case the calculated values are much higher than the percentages found for glycol ash. It may therefore be concluded that the differences between heat ash and glycol ash are not to be ascribed mostly to the presence or absence of CO_2 as was done for enamel.

Is Organic Phosphorus Converted to Inorganic Phosphate?—It has been suggested that in heat ashing some of the phosphorus from the organic matrix is converted into inorganic phosphate and retained in the heat ash. In the next table the values for the constituents of the heat ash of enamel and of dentin are compared.

Ash	*Ca*	*Mg*	*P*	*Ca/P*
Enamel heat ash	38.2	0.80	18.7	2.05
Dentin heat ash	38.0	1.49	18.9	2.03

With the exception of the higher magnesium in dentin, these values are practically identical. It would therefore appear that, if phosphorus is deposited from the organic matter during heat ashing, there is a proportionate gain of calcium. Since dentin contains some 28 per cent "organic matter" as compared to roughly 1/10 this amount in enamel, and since the organic matter presumably would be rich in phosphate, it seems improbable that much phosphorus had been fixed as phosphate during ashing; because if phosphate had been formed, the dentin should have had a considerably different phosphate content and calcium/phosphorus ratio from enamel.

Loss of Calcium and Phosphorus During Glycol Ashing.—In the search for an explanation of the low values of calcium and phosphorus in the dentin glycol ash, the loss of unknown extractables might be considered. By comparing the values for glycol-ashed enamel and dentin, some evidence of the magnitude of the effect may be gained.

Ash	*Ca*	*Mg*	*P*	*Ca/P*
Enamel glycol ash	37.6	0.67	18.4	2.06
Dentin glycol ash	35.5	1.39	16.7	2.15

It may be recalled that about 1 per cent of unknown extractables were lost from the glycol-ashed enamel and about 2 per cent from the glycol-ashed dentin. The calcium and phosphorus percentages are lower in dentin than in enamel, so it is assumed that both are lost to a greater degree in dentin; however, more phosphorus is lost than calcium as shown by the increase in the calcium to phosphorus ratio. It is possible to make a few simple calculations to test this hypothesis. Based on the assumption that the glycol ash represents a heat ash plus CO_2 minus unknown inorganic extractables, the calculations in the next table were made.

Ash	*Ca*	*Mg*	*P*	*Ca/P*
Dentin heat ash	38.0	1.49	18.9	2.01
Dentin heat ash plus 3 per cent CO_2	36.9	1.45	18.3	2.01
Above mixture minus 2 per cent Ca	34.9	1.42	17.9	1.95
Above mixture minus 2 per cent P	36.2	1.42	16.3	2.21
Above mixture minus 0.5 per cent Ca minus 1.5 per cent P	35.8	1.42	16.7	2.14
Dentin glycol ash	35.5	1.39	16.7	2.15

In the first line of the last table the composition of dentin heat ash is given. In the second line, the calculated composition of a mixture of dentin heat ash plus 3 per cent CO_2 is given; for each constituent the percentages are slightly lower. It was next assumed that all of the loss in the extraction process was calcium. This gave, as shown in the third line, a calcium percentage considerably too low to correspond to the actual value in glycol ash (last line); and a calcium/phosphorus ratio of 1.95 as against the value of 2.15 found in glycol ash. It seems improbable that the loss on extraction was exclusively calcium. Next it was assumed that all of the loss in the extraction process was phosphorus. As shown in the fourth line, this gave a value of calcium somewhat too high and of phosphorus somewhat too low, with a high calcium/phosphorus ratio of 2.21; therefore, it seems improbable that the loss on extraction was exclusively phosphorus.

It was finally assumed that the loss on extraction amounted to 0.5 per cent calcium and 1.5 per cent phosphorus. The calculations based on this assumption gave values for Ca, Mg, P, and Ca/P ratio (Line 5) which are strikingly similar to the composition actually found for the glycol ash. It is therefore concluded that dentin heat ash and dentin glycol ash differ in the following particulars: (1) the absence of CO_2 in heat ash, (2) the loss of a small amount of calcium and a larger amount of phosphorus in the alkaline glycol extraction.

That phosphate may be adsorbed by the ash from the alkaline glycol solution was demonstrated by Manly and Levy[16] but their interest lay only in calculating that, with the relatively low specific activity of the extracted phosphate, negligible radioactivity would be taken up by the powdered tooth tissues. In contrast, the specific activity of the extractable phosphate in the experiment carried out by Neuman and Riley[17] is high, in fact, high enough to make a sizable contribution to the total radioactivity of the hard tissues. They showed that approximately 25 per cent of the radiophosphate added to the glycol could be found ultimately in the ash. The mechanism of this transfer is probably an exchange phenomenon in which phosphate dissolved in the glycol exchanges with the surface phosphate of the microcrystals of apatite.[18] The important aspect of this exchange is that the phosphate in glycol solution plays an essential part, that is, the amount of phosphate is one of the controlling factors in the exchange.

The recognition of this relation caused Neuman and Riley[17] to analyze the glycol solutions for the total amount of phosphorus extracted from several samples of rat femurs during the ashing process. They found on the average about 0.6 mg. of phosphorus in the glycol solution; this should be compared with around 5 mg. of phosphorus in the femur ash. Let us assume that in the ashing procedure 50 per cent of the dry weight was leached out (organic matter). Bone protein contains of the order of 0.2 per cent phosphorus, consequently, the amount of phosphorus in the glycol which can be attributed to protein may be estimated as not over 0.07 to 0.1 milligrams. Of the 0.6 mg. of phosphorus, approximately 0.5 mg. presumably came from inorganic phosphorus and from other organic phosphorus sources than protein. In the comparisons of the heat ash and glycol ash presented above, it was suggested that in the case of dentin a satisfactory explanation of the differences could be made if it were assumed that 2 per cent of the inorganic phosphorus were extracted in glycol. Using

Neuman and Riley's figures, 2 per cent of 5 milligrams is 0.1 milligrams. This amount of phosphorus coming from the inorganic part would be possible and would still leave 0.4 mg. of phosphorus in the glycol solution to be attributed to other sources.

SUMMARY

1. About fifty teeth were separated into enamel and dentin. An aliquot of each tissue was then ashed by incineration (heat ash) and another by extraction with 3 per cent KOH in ethylene glycol (glycol ash). Calcium, magnesium, and phosphorus analyses were made on every ashed aliquot.

2. Incineration drives off CO_2 so that the heat ash always was a smaller percentage of the dry weight than was the glycol ash which contained all of the CO_2. The percentages of calcium, magnesium, and phosphorus in the heat ash were therefore higher than in the glycol ash.

3. In the enamel samples, the glycol-ashing procedure apparently removed about 1 per cent of unidentified extractables presumed to be inorganic constituents.

4. In the dentin samples, a larger loss of extractables occurred, amounting to about 2 per cent of the dry weight. Calculations were made to show that a small loss of calcium (of the order of 0.5 per cent) and a larger loss of phosphorus (of the order of 1.5 per cent) would give a glycol ash having the composition actually found.

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AN ELECTRONIC STRAIN GAUGE FOR MEASURING ORAL FORCES

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INTRODUCTION

NUMEROUS instruments have been devised for measuring the maximum biting force. The literature prior to 1938 has been adequately covered by Brawley and Sedgwick[1, 2] who found thirty-one references to different instruments for measuring biting force. The principles involved in construction of these devices included use of simple levers, springs, manometers or combinations of these principles, and steel ball impressions. Since that date, instruments have been developed by Worner,[3] Boos,[4] and Losch,[5] and a technic was suggested by Baker, Brekhus, and Dowell.[6] In Worner's device, the biting force was transmitted from a plunger to a liquid and registered on a pressure gauge. The equipment employed by Losch consisted of a Sylphon bellows through which pressure was applied to a liquid and registered on a manometer. It was similar to the equipment used by Brekhus and Armstrong[7] and by Waugh.[8] The device prepared by Boos was applicable only for measuring forces between dentures. The technic suggested by Baker, Brekhus, and Dowell are similar in principle to that recommended by Koehler and Etling.[9]

It seems evident that the most suitable instrument for measuring biting force will be one with the minimum size for the part on which the force is exerted. During actual chewing the teeth are very nearly in contact when the maximum forces are being exerted. For this reason the bite element should be thin enough to permit observations to be made when there are only a few millimeters of bite opening. Of course, a thin basic element can be adapted to experiments where greater bite opening is desired. The element should also be narrow enough to permit measurements to be made on any tooth in the mouth. Furthermore, it would be desirable to have the bite element not connected to heavy or bulky equipment and to have it capable of withstanding sterilization. The completed instrument should have adequate precision. It is interesting that essentially these requirements were set forth by the Rotterdam Dental Society in 1911 in an effort to stimulate development of a suitable instrument.[10] Their size requirement was that the bite element should be small enough to enter an aperture 1 cm. square. Regarding precision, they stipulate an error not over six pounds below 120 pounds, and not over twelve pounds between 120 and 330 pounds. There is no record that these requirements were ever met.

Many of the instruments which have been reported for measuring oral forces could not be applied to measurements on a single tooth without modification. Those designed by Friel,[11] Black,[12] Johnson and Hatfield,[13] Brawley and

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Sedgwick,[2] Worner,[3] and Losch[5] were actually used on single teeth. Klaffenbach[14] applied Black's device to measurement of forces on molars, premolars and first incisors. Few of these devices could be employed to measure the forces exerted by single lower incisors because of the width of the bite element. In nearly every case the bite opening amounted to more than 10 millimeters. It was 18 mm. with Black's instrument, 12 to 18 mm. with Losch's equipment, and unspecified in other cases.

In 1943 Kelly and Langheinz[15] reported a procedure for determining the proper vertical dimensions for denture patients by means of an instrument designated as a "vertigraph." Photographs of this equipment were included, but there was no description other than the statement that the bite element was an electronic control operated by pressure on a reactance disc. Since the disc seemed to be thinner than the bite element of other instruments commonly employed, further information was requested from the authors. The instrument was generously made available to us for inspection, but since it was not in operating condition at the time, no observations were possible. Our examination of this equipment encouraged us to consider the development of an electronic device for oral force measurement. It seemed feasible to one of us (AHH) that a device could be constructed on the principle of inductance variation caused by the movement of a conducting spring located near an inductance coil. By this means, a truly elastic system might be obtained which would permit the indicating meter to return to zero immediately after the biting force was removed. This would not possess the disadvantage stated to be inherent in the Kelly and Langheinz apparatus, namely, that one hard bite would cause the apparatus to be thrown out of adjustment and require recalibration.

From the literature on forces to be expected in measurement of maximum bite it was decided that a proper instrument should measure forces from a few pounds up to 300 pounds. The measuring element which was to be introduced into the mouth was to be kept small but no requirements were placed on the size or operation of the associated electronic equipment. It was of course understood that the associated equipment must be free from the possibility of giving a shock at the bite element and that it should not require any elaborate operating procedure.

DETAILS OF THE INSTRUMENT

Principle of the Measuring System.—In planning a device to meet the requirements outlined above, a number of possible types of electronic strain gauges were considered. Resistance strain gauges are widely used but are less attractive for reasons of temperature and leakage considerations. Capacitance would be very difficult to use because the magnitude of the variation producible is extremely small and capacitance would be affected by moisture. The strain gauge selected for development employs an inductance as the parameter which is varied by the biting force. The principle is that the inductance of a coil is lowered when a conducting material is brought near the coil. This principle is utilized in the bite element by mounting an inductance coil and a conducting silver foil in an elastic system which is deformed a small amount when a biting

force is applied. The deformation allows the silver foil to move nearer to the inductance coil and to lower its inductance. Thus force is converted to a change in separation between the coil and the silver foil, and this change in separation gives a change in inductance. An electronic circuit is provided which responds to this change in inductance and causes the change to be registered on a DC microammeter.

The Bite Element.—A sketch of the bite element is shown in Fig. 1. The elastic system is produced by mounting a flat spring in a U-shaped support, the flat spring being held in place by a tight-fitting, dove-tail joint. A button on top of the spring allows the force to be applied at the center of the spring. When force is applied, the spring is bent downward at the center by an amount proportional to the force. The thickness of the spring is so chosen that a deflection of 0.005 inch to 0.010 inch is produced at the center of the spring for full biting force. The support is sufficiently strong that it experiences little change in shape.

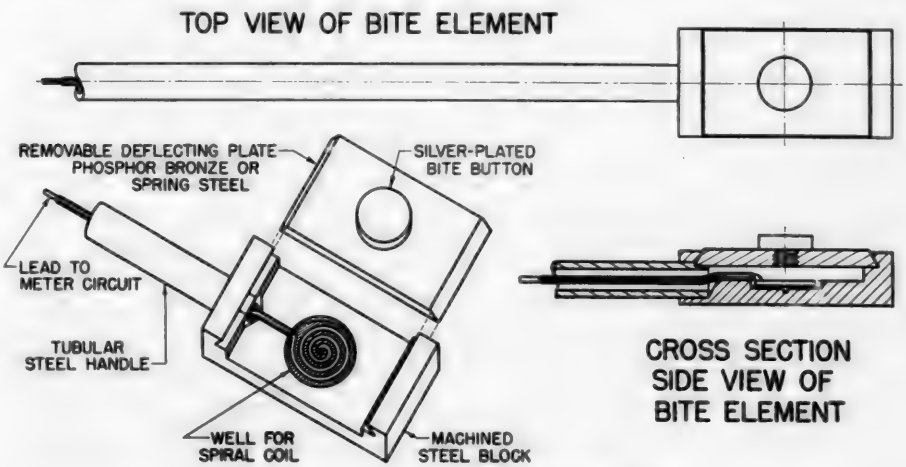

Fig. 1.—Bite element for oral force meter.

The bottom of the spring is silver-plated to form a thin silver foil which moves with the spring. The inductance coil is a flat spiral of wire cemented to the upper surface of the U-shaped support, or located in a shallow well formed in the upper surface of the support. The leads to the coil are brought in through the thin-walled steel tube. For elements which are to measure large biting forces, the springs are made of heavy steel, and for those experiencing only small forces, thin phosphor bronze strips are used. A single support can be equipped with several springs to accomplish changes in range. While a single support can be used with a variety of springs, it is preferable to have a number of complete bite elements to provide the change in range. In the equipment used so far, the elements differ only in the strength of the spring, but the more sensitive ones could be made thinner because they do not have to be so strong.

Associated Electronic Equipment.—The function of the associated electronic equipment is to register in a convenient way the variation of inductance produced in the bite element. This is accomplished by using the variable inductance as a part of a tuned circuit which is coupled to an oscillator. The oscillator is so adjusted that its amplitude of oscillation is considerably influenced by the presence of the coupled circuit of which the bite element is a part. When the coupled circuit is tuned to the oscillator frequency, the amplitude of oscillation is low; when the coupled circuit is tuned away from the oscillator frequency, the amplitude of oscillation is increased. The coupled circuit acts as an absorbing system to drag the amplitude of oscillation down. The drag effect is greatest when the coupled circuit is tuned to the oscillator frequency, and the effect becomes progressively less as the tuning is moved away from the oscillator frequency.

In operation the coupled circuit is made to resonate at the oscillator frequency, thereby producing maximum drag, when no biting force is applied, and it is progressively detuned as the biting force is exerted. Thus the drag decreases with the application of a biting force so that the amplitude of oscillation increases with biting force.

Since the magnitude of the grid current in an R. F. oscillator gives a measure of the amplitude of oscillation, this D.C. current was used to register the biting force. The initial grid current is balanced out and the recording system shows only the increase caused by the application of a biting force.

The circuit used in the first model of the electronic oral force meter is shown schematically in Fig. 2. It consists of three parts, a regulated power supply, a Hartley oscillator operating at 3 megacycles per second, and a tuned absorbing circuit. The regulated power supply is shown at the right, and it involves only a conventional VR-tube to eliminate fluctuations due to line voltage changes. The oscillator is a shunt-fed Hartley circuit in which the normal grid current is balanced out of the meter by adjusting the 20 K potentiometer shown near the center of the diagram. The meter has a 150 ohm shunt across it in normal operation. A switch allows this to be removed to obtain increased sensitivity when making initial adjustments. The third part of the circuit is the absorbing loop shown in the lower left part of the diagram. It consists of a fixed inductance for coupling with the oscillator, the variable inductance of the bite element, and a variable capacitor for tuning to the oscillator frequency, which is fixed.

The circuit is operated in the following way: The system is turned on and allowed to warm up for a few moments, after which the absorbing loop is tuned to the oscillator frequency by varying the adjustable capacitor. The proper setting is the one which gives minimum meter reading, corresponding to maximum drag and minimum amplitude of oscillation. The size of the minimum reading is of no importance. Next the 20 K potentiometer is adjusted until the meter reads zero, which causes the normal grid current at maximum drag to be balanced out of the meter. The system is now ready for use if these adjustments have been carefully made. An alternate procedure is to make

the above adjustments in a preliminary way and then to open the switch *S* which removes the shunt and makes the meter much more sensitive. A final adjustment is then made on the variable condenser to obtain an exact minimum in meter reading which corresponds to maximum drag and exact tuning of the coupled circuit to the oscillator frequency. The switch is then closed and the zero carefully set before proceeding with measurements.

Characteristics of Actual Equipment.—The photograph, Fig. 3, shows the physical form of the equipment described in this paper. The bite element is being compressed in a subject's anterior teeth and the associated electronic equipment sits at the right. The two controls are shown at the bottom of the front panel, the tuning control on the left, and the zero adjusting control on the right. Two switches are located on either side of the meter; one is the main power switch, and one is for removing the meter shunt so that more exact tuning can be accomplished. The bite elements plug in at the center of the panel, below the meter, near the bottom.

It has been found that four different ranges of bite elements are required in order to measure all of the forces which may be observed in the mouth. A thin spring is employed to provide a bite element with a range of 1 to 5 pounds

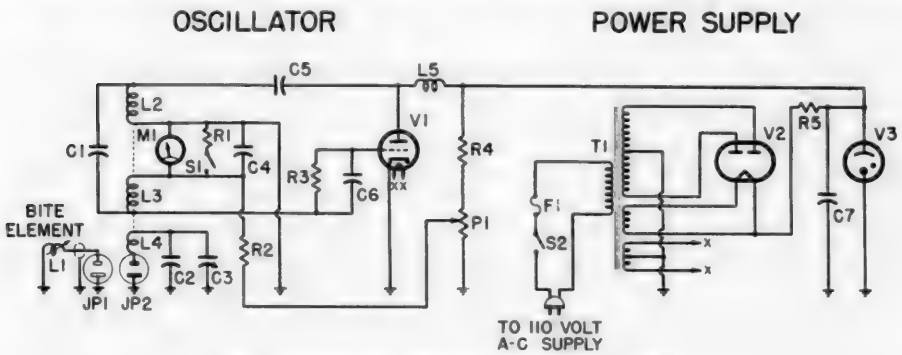

Fig. 2.—Schematic diagram of oral force meter.

PARTS LIST

CAPACTORS

C1 150$\mu\mu$f.
C2 Selected Value
C3 50$\mu\mu$f. Trimmer
C4 0.01 μf.
C5 0.01 μf.
C6 0.001 μf.
C7 2.0 μf.

RESISTORS

R1 150K ohms
R2 10K ohms
R3 10K ohms
R4 40K ohms
R5 3500 ohms

POTENTIOMETER

P1 20K ohms

INDUCTORS AND TRANSFORMER

L1 Bite element coil
L2 10 turns
L3 10 turns } all with a common axis
L4 5 turns
L5 2.5 millihenries
T1 Thordarson 13R19 transformer

VACUUM TUBES

V1 615 Triode Oscillator
V2 5W4 dual diode rectifier
V3 VR-105 Voltage regulator

OTHER COMPONENTS

F1 1 Amp. fuse
M1 0-100 Microamp. meter
S1 SPST range-changing switch
S2 SPST power switch
JP1 2-pin connector plug
JP2 2-pin connector socket

and this can be used for estimating the maximum forces which can be exerted by the lips. A second element with a range of 5 to 30 pounds seems to cover the majority of full denture cases. A third has the range from 30 to 100 pounds and that is useful chiefly in recording forces between anterior teeth, while the fourth with a range of 100 to 300 pounds is suitable for measurements of forces between premolars and molars. A separate calibration chart was provided for each element in order to convert meter readings to pounds of force.

Fig. 3.—Oral force meter in operation.

The operation with the above ranges is good. However, it is not advisable to use the elements much outside the stated ranges. For example, a 50-pound force should not be measured on the 300-pound element. This is because the drag action associated with the first increments of inductance change is smaller than that which accompanies the additional increments, and this makes any given bite element insensitive for forces less than about 25 per cent of its maximum value. This nonlinear response is being eliminated in a second model of the equipment which will be described at a later time.

A big advantage of the variable inductance system is that it is not affected by the temperature and humidity variations which are experienced in normal use. It is furthermore constructed of materials which will withstand sterilization.

The bite elements are 9 mm. wide and 6 mm. thick before any cushioning materials are added. The instrument is entirely free from shock at the bite element and it is very easy to operate. It requires less than a minute to adjust, and after it has been adjusted it holds its adjustment in a satisfactory way. The bite element is perfectly elastic in that the meter returns immediately to zero when the biting force is removed.

EXAMPLE OF APPLICATION

A study was made of the variation in maximum biting force by repeated readings taken on the same subjects over a period of several days. The data in Table I shows the average bite in pounds for all maxillary teeth for each subject. The standard deviation of a single determination was calculated from the five or six readings on each tooth. The average forces ranged from 24 to 198 pounds. The subjects were normal men, 20 to 30 years of age.

TABLE I
REPRODUCIBILITY OF MAXIMUM BITING FORCE MEASUREMENT

MAXILLARY TEETH	7	6	5	4	3	2	1	1	2	3	4	5	6	7
SUBJECT M. O.														
Ave. bite lbs.	101	101	63	60	48	34	37	40	34	44	48	75	102	104
Per cent deviation	15	21	26	22	24	16	4	22	24	8	18	35	16	9
SUBJECT W. E.														
Ave. bite lbs.	131	133	82	55	31	29	31	32	28	35	52	74	115	132
Per cent deviation	5	15	38	35	12	10	7	24	15	11	15	39	23	14
SUBJECT L. I.														
Ave. bite lbs.	88	93	x	72	54	35	34	29	24	x	51	x	91	92
Per cent deviation	25	21	x	10	12	23	13	18	16	x	7	x	29	30
SUBJECT S. T.														
Ave. bite lbs.	186	184	84	70	73	54	51	45	44	75	103	89	198	188
Per cent deviation	18	21	21	23	14	10	10	15	26	3	29	23	17	18

The range of deviation varied from 4 to 38 per cent of the average value, for the standard deviation of a single determination. It appears evident that a single determination of biting force is apt to give values which differ considerably from the mean of several determinations. For this reason the first two values were averaged and compared with the mean of all the readings on the same tooth. The average of two readings showed less variation. Half the variations were less than 9 per cent, and 95 per cent of the variations were smaller than 23 per cent. It is recommended that two readings should be taken whenever convenient.

SUMMARY

An electronic strain gauge has been devised for measuring oral forces, which makes use of the principle of change in inductance of a coil as a silver plated spring is brought near the coil. The deflection of this spring is proportional to the force applied and the deflection produces a change in inductance. The coil is part of a tuned circuit which is coupled to a radio-frequency oscillator. Force applied to the spring changes the inductance and tunes the coupled circuit away from the oscillator frequency. This permits the amplitude of

oscillation to increase and the magnitude of the grid current in the oscillator is used as a measurement of biting force.

A set of four elements are employed to cover the ranges of forces involved. The ranges are 100 to 300 pounds, 30 to 100, 5 to 30, and 1 to 5 pounds.

The bite element is narrow enough to permit maximum force readings on any tooth in the mouth with a bite opening of 7 to 10 millimeters. The bite element is small, light, unaffected by temperature and moisture, and capable of withstanding sterilization.

The authors wish to acknowledge the fact that the data in Table I were obtained by Dr. J. T. O'Rourke and Miss Louise C. Braley.

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INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

Scientific Proceedings of the New York Section

The Guggenheim Dental Clinic of New York—April 29, 1948*

Samuel C. Miller, *Editor, New York Section*

1. Histochemical studies of the developing dental tissues with specific reference to odontogenesis. *Gerrit Bevelander, College of Dentistry, New York University, New York, N. Y.* By histochemical methods the localization and distribution of alkaline phosphatase in relation to the embryogenesis, differentiation, and calcification of the dental tissues have been investigated. These studies, involving particularly osteogenesis, odontogenesis, and amelogenesis as well as later development of bone, dentin, and enamel indicate that alkaline phosphatase may play a role in the development of calcifying tissues. Significant correlations are made between histochemical and previous micro-incineration studies in relation to the pattern of calcification. Comparisons with other integumentary derivatives such as hair, claw, nail, and feather, which do not calcify, present patterns which are similar to that of teeth.

2. Histochemical studies of the developing dental tissues with special reference to amelogenesis. *Percy L. Johnson,† College of Dentistry, New York University, New York, N. Y.* Abstract involved in above.

3. Variation in salivary protein concentration. *Robert J. Gorlin, School of Dental and Oral Surgery, Columbia University, New York, N. Y.* In the course of investigation of salivary protein by the Tiselius electrophoretic apparatus, the author observed variation in both the pattern and mobility of the several components. The variation led to this study of salivary protein to determine whether a constant amount of protein could be obtained by uniformity in the collection technic. This was undertaken because the work of Krasnow and Karshan, and Tannenbaum and Beakins had demonstrated wide variations in protein values existing in saliva. Mean values in several studies have established salivary protein concentration to be 260 to 300 mg./100 c.c. of saliva. However, the standard deviations in these studies have varied from 45 to 118, demonstrating the wide range of values. In this study, several variables were made constant, that is, salivary samples were uniform as to the amount collected (5 c.c.), time of salivary stimulation (2 minutes), size of paraffin block ($1 \times 1 \times \frac{1}{2}$ cm.), and collection analysis-interval ($\frac{1}{2}$ to 1 hour). Samples were taken from 35 volunteers who had had no breakfast, for purpose of minimizing the effect of protein intake. The effect of smoking and water intake upon salivary protein concentration was not determined in this study. The method of Greenberg, as adapted for salivary protein by Krasnow, was utilized on 1 c.c. samples. A mean value of 280.37 mg./100 c.c. saliva was obtained. The standard deviation was 65.93 and the standard deviation of the mean was 11.31. It may be concluded from this study that control of the above-mentioned factors has no effect upon the variation of salivary protein concentration.

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*Presiding—Frances Krasnow.

†Guest.

INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

Scientific Proceedings of the New York Section

The Guggenheim Dental Clinic of New York—October 28, 1948*

Frances Krasnow, *Editor, New York Section*

1. Studies in dental public health administration. IV. Dental caries experience of New Jersey school children. *J. M. Wisan† and N. W. Chilton, New Jersey State Department of Health, Trenton, N. J.*

2. Relative efficacy of 27.5 per cent ammonium therapy dentifrice. *Chester J. Henschel and Leon Lieber†, Eastern Graduate Research Group, New York, N. Y.* The dental histories of 220 carefully observed private patients indicate an apparent caries incidence reduction of 35.2 per cent compared with an auto-control period; 37.5 per cent compared with control group, same period. The cases, 44 per cent male, 56 per cent female, fell into four groups: 1. 100 consecutive cases, average total observation 10.7 years; average present age 37.5; 3.8 teeth missing from full complement; 7.8 years auto-control for determining average DMF using cosmetic dentifrices = 2.39 DMF/year; 34.3 months using ammonium dentifrice = 1.55 DMF/year; DMF rate increased in 18 cases, decreased in 82 cases. Home care not supervised directly. 2. 50 consecutive cases as check control group, average total observation 12 years using cosmetic dentifrices, with average DMF established for arbitrary periods of (a) first none years = 2.31 DMF/year; (b) last three years = 2.48 DMF per year; DMF rate increased in 25 cases, decreased in 25 cases; average DMF/year increase 7.3 per cent. 3. 30 consecutive cases of complete operative rehabilitation, average age 35; 5.8 teeth missing; average observation after completion of treatment 2.3 years using ammonium dentifrice = 1.00 DMF/year. 4. 40 consecutive cases; average age 9.8; total observation period using ammonium dentifrice, 2.3 years = 1.74 DMF/year. All calculations were made from permanent office records based upon field periodic periapical full series and yearly bite wing radiographs. Some proportion of the apparent caries incidence reduction may be attributed to enthusiastic oral hygiene heightened by the knowledge of the possible therapeutic benefit of the dentifrice.

3. Interpretation of topical sodium fluoride findings. *Frances Krasnow, Guggenheim Dental Clinic, New York, N. Y.* Reported examinations,‡ one year after four to fifteen applications, indicate differences between treatment and nontreatment varying from 2.8 to 5.1 NEW DF§ TEETH per 100 originally noncarious teeth—the average rate being 3.6 per cent; for of 7869 treated noncarious teeth, 402 (5.1 per cent) developed caries and of 7849 untreated noncarious teeth, 687 (8.8 per cent) developed caries. Thus, the effect due to fluoridization is a reduction in new DF teeth equal to 3.6 per 100 tested. After two years, the reduction rate is still 3.1 per cent for 1903 and 1871 teeth respectively; but at the end of three years with 1652 and 1560 teeth, it falls to 1.5 per hundred. The extensively employed figure of 40 per cent is only a relative value, extensively interpreted as meaning that 40 teeth of every 100 are saved from decay by four applications of the 2 per cent sodium fluoride

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†By invitation.

‡*Public Health Reports* **58**: 1701, 1943; **60**: 1085, 1945; **61**: 1683, 1946; **62**: 1477, 1947.

§DF = decayed or filled.

solution. Not only does this magnify the basic rate per cent tenfold, but like relative percentages may result from different basic rates and vice versa. Hence, unjuxtaposed by the meaningful statistic of rates per cent, relative percentages do not convey completeness of connotation. Especially is this so when the rates are comparatively small. In the calculations pertaining to the large proportion of the remaining noncarious teeth, the difference between the respective rates per cent, 94.8 and 91.2, practically simulates the relative percentages.

4. THE EFFICIENCY OF VARIOUS STRENGTHS OF PROCAINE AS USED IN EXODONTIA. *Isaac Neuwirth, William B. Sweder,† Walter Mullon,† Henry Marshall,† and Edward B. Gretsch, College of Dentistry, New York University, New York, N. Y.* Results following inferior alveolar injections of different potencies of procaine for exodontia were reported.

5. THE ROLE OF THE GINGIVAL BIOPSY IN THE DIAGNOSIS OF SECONDARY AMYLOID DISEASE. *Robert J. Gorlin and Robert Gottsegen, Faculty of Medicine, Columbia University, New York, N. Y.* A method for the diagnosis of secondary amyloid disease by means of gingival biopsy was reported by Selikoff and Robitzek in 1947 and is here brought to the attention of those interested in oral pathology. The characteristic diagnostic triad of hepatosplenomegaly, proteinuria, and edema are present in less than 25 per cent of the cases and the Congo-Red dye test, although valuable, is deficient in several respects. Secondary amyloidosis, as the name implies, is secondary to a chronic disease such as tuberculosis, osteomyelitis, or syphilis There is an abnormal protein, amyloid, deposited in the walls of arterioles or beneath the endothelium of capillaries or sinusoids in areas of great vascularity such as the liver, spleen, adrenal glands, and kidneys. The gingivae, which are always grossly normal in appearance, may have microscopic amounts of amyloid present in the papillary layer of the corium. In 78 per cent of Selikoff and Robitzek's cases in whom the clinical diagnosis of amyloidosis had been established with reasonable certainty, the gingival biopsy was positive for amyloid. A negative biopsy, therefore, does not rule out the possibility of amyloidosis. However, five patients in whom amyloidosis was suspected but not proved clinically, and who showed only partial absorption of the Congo-Red, were found to have positive gingival biopsies and, subsequently, amyloidosis was documented by inspection of other tissues. It is in cases such as these that this method has its greatest value. Serial sections, and, when possible, several pieces of tissue should be examined, for the amyloid may appear in only small quantities in scattered areas. A method of tissue preparation and staining for the demonstration of amyloid is presented.

6. A METHOD FOR DETERMINING LABIAD-LINGUAD DENTAL ARCH RELATIONSHIP OF THE MANDIBULAR BASAL ARCH IN ORTHODONTIC TREATMENT PLANNING. *J. A. Salzmann, New York, N. Y.* A method is presented whereby the Labiad-Linguad dental arch relationship of the mandibular incisors and the entire mandibular dental coronal arch are measured in relation to the base of the mandible, the gonion angle, and the prementon point. These measurements are used as a basis in determining the adequacy of the basal arch for the accommodation of the mandibular teeth in regular alignment and the probable effects of such orthodontic alignment on alveolo-dental prognathism. The need for reduction of dental units (extraction) is thus based on criteria as they apply to the individual patient.

†By invitation.

INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

Scientific Proceedings of the Philadelphia Section

TEMPLE UNIVERSITY DENTAL SCHOOL, NOV. 8, 1948.*

S. LEONARD ROSENTHAL, *Editor, Philadelphia Section*

1. A MECHANISM FOR THE SOFTENING AND SOLUTION OF THE DENTIN IN CARIES. *Milton B. Engel, University of Illinois, Chicago, Ill.* The ground substance of connective tissue is a carbohydrate-protein complex polymerized in varied degrees with the aid of mucolytic enzymes. The usual methods of fixation and preparation of sections so alter them that accurate determinations are impossible. A quick freezing-drying method together with Hodgkiss staining overcomes many of the disadvantages of other methods. Since ameloblasts, odontoblasts, and dentin are highly polymerized and insoluble at pH 1 to 10, and since the matrix of enamel and dentin is soluble at pH 1 to 5.5, carious processes must begin with the matrix. Sections of carious dentin show an initial depolymerization of the dentinal fiber followed by a similar process of the matrix. Sections show the presence of hyaluronidase or a hyaluronidaselike enzyme. Cultures of streptococci exhibit a similar substance.

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*Paul E. Boyle presiding.

INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

Proceedings of Twenty-Sixth General Meeting
Sheraton Hotel, Rochester, N. Y.

June 18, 19, and 20, 1948

Compiled by Hamilton B. G. Robinson, Editor,* *College of Dentistry, Ohio State University, Columbus, Ohio*

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I. Inaugural Address: Our Common Field of Research

Allan G. Brodie, D. D. S., Ph.D., College of Dentistry, University of Illinois, Chicago, Ill.

It has become customary in this society for the incoming president to make some sort of inaugural address and for a number of years it was accepted practice for the address to concern itself with the president's own field of research. Fortunately this tradition has been broken several times and you will therefore be spared the pain of following the intracacies of the growth of the facial skeleton, a field that, judging from the proceedings of this and other of our meetings, holds little interest for any except a few misguided individuals. I have elected rather to talk on something about which I know far less but which does concern all of us and should concern us more deeply. I refer to dental education.

When, some four years ago, I was asked to assume a deanship and was weak enough to accept, I entered a field that had vaguely irritated me for a number of years. I had been very critical of the job that was being done by dental schools in general and, of course, of our own in particular. As a teacher of graduate students for a decade and a half, I had had students from most of the better dental schools in this country and had found little difference among them. They were carefully selected, yet they all showed the same deplorable lack of knowledge of everything other than technical procedures. One could wonder at a system in which they were exposed to so much and retained so little. At the graduate level most of them performed satisfactorily. They demonstrated keen interest and the ability to work hard. All of them developed a very critical attitude toward the dental training they had received and they repeatedly asked

*The meetings of the International Association for Dental Research preceded the meetings of the American Association of Dental Schools on June 21, 22, and 23, in Buffalo, N. Y.

The Editor wishes to express his appreciation for the cooperation of General Secretary Edward H. Hatton in preparation of these Proceedings.

why that training had not given them the background that they now found so necessary. I finally realized that my own experience, which I had considered to be peculiar to me, was a rather universal one.

When I was finally forced to grapple with this problem as an administrator, I found myself spending hours instead of minutes considering its many ramifications and arriving at conclusions that were quite at variance with some of my most cherished precepts. The fundamental problems of the question seemed to lie far remote from the field of dentistry and to involve factors to which we pay little or no attention. Owing to a lack of scientific method that might yield objection data, the experimenter in this field is forced to rely quite largely on his own experience and reactions and those of his intimates. In addition to this, there are a few pretty well-established psychological precepts that prove helpful, and the lessons of history are of course always at hand. Since the problem is one of education it can be examined in the light of general educational patterns.

An educational system designed for the genius requires little planning. He will survive the worst that can be done to him. Education for large groups, however, implies variation in capacities and it becomes necessary to think of factors and objectives basic enough to embrace all. Our primary and secondary school system is much the same wherever found because of a general recognition of this fact. There is inherent in it a recognition of the gradual maturing of the mental processes which in turn depends on changing physiological stages. During adolescence there is an awakening that is normally characterized by the beginning of concept formation and a dawning sense of responsibility.

In the high schools and the colleges of liberal arts and sciences as well as in the grammar schools, there are somewhat generally accepted curricular patterns. In the colleges, the curriculum embraces a limited number of subjects and the areas are separated quite widely, affording a mental change of pace. Since the areas are large there is the necessity of teaching principles rather than details, and finally, but quite as important, there is free time for discussion and assimilation. Likewise, throughout the period of elementary, secondary, and college education, the modern concept that good teaching utilizes and nourishes the curiosity of the student determines the approach.

Professional education offers a striking contrast. Whereas general education attempts to take the responses of the student into account, professional education pays all its attention to the subject rather than to the individual studying the subject. If the general principles here enumerated can be accepted as correct from the psychological point of view, professional education ignores all of them.

Medical education is constantly held before dentistry as a model to be emulated, and the great contributions made by medical scientists are offered as proof of the correctness of its educational system. A critical appraisal of certain other factors, however, lead one to question whether this is a justified assumption. Let us look at some of these factors for a moment.

The prime factor in the success of any human endeavor is the quality of personnel engaged in it. Here medicine can claim great success because it attracts some of our brightest and most altruistically-minded young people. The reason for this is not too hard to find.

The past forty years have witnessed the rise of a number of social heroes. The banker was one of the first and he was followed by the civil engineer. During World War I the aviator came in for a term of worship but he was eclipsed quite completely by the chemist and by the physicist so that his infinitely greater contribution to destruction during World War II was accepted as routine.

Slowly over these years, however, a new hero was being built up by those king makers, the press and the radio. He was the "Man in White." He held

death at bay, he fought microbes and hunger, he sat all night by dying children after driving miles through blizzards. And he never expected a fee! As a result of this propaganda, the doctor is the hero of modern society and it is a very human trait to wish to be a hero.

But society has not stopped here. It has lavished on this hero hundreds of millions of dollars in the form of hospitals, medical schools, research institutions, and endowments and this unbeatable combination of man power and money has only accelerated the trend.

Actually, these benefits have accrued to medicine through the labors of relatively few men, principally laboratory scientists not engaged in practice at all, but so thoroughly has the public come to identify this research with the medical field that the title doctor strikes awe. Is it any wonder that the M.D. degree is the most coveted of all degrees today and the one for which the young aspirant will go through torture? It is the passport to the heights of social leadership and respectability.

But the question remains whether it is the course of instruction in medicine that has led to all these benefits. Given good students under the pressure of intense competition, and almost any system of education will show some desirable results. It would be interesting however to know the percentage of success among average medical graduates, that is, how many can be considered well trained for the scientific practice of medicine.

The medical curriculum is the result of the experience of physicians through the ages. This experience began with curiosity about the world and man, and led to empiricism—but the curiosity and the empiricism were pretty well blunted by seven hundred years of reliance on authority and dialectics. And even though the nineteenth century saw the introduction into medicine of the scientific method, there is ample evidence that the tendency to rely upon authority and tradition is not entirely dead. For the past fifty years or more medical education has been pretty well frozen in the Johns Hopkins pattern which lays great emphasis on the study of the basic sciences and insists that these fields be covered before any contact with patients is allowed.

Dentistry, viewing the popularity of medicine and assuming that it could be credited to medicine's course of training, adopted the same course for its own. This was only logical, particularly so when it was more economical to teach the two groups of students together than to set up separate training courses for each. But the differences that existed in the two fields in the matters of discipline and motivation were not sensed. As indicated before, the reason the system seems to work for medicine is the competition-induced discipline. The system was applied to dentistry with an air of "take this, damn you, it will make a man of you." And this is the face of a falling index and at a time when the voice of authority was being challenged as never before.

The problem that is posed seems to be a determination of whether our objectives can be gained or at least more closely approached by a study that includes some slight regard for the reactions of our guinea pig—the dental student.

Society, and even the dental profession at large, look at dentistry in a different light from that of the dental educator and research man and it is the attitude of society that the average dental student brings to college with him. He expects dental laboratory and clinical work as soon as he arrives and he finds that he must forego these for another two years while he studies more books. True he spends some time at the laboratory bench but this is broken into repeatedly by the flunking courses in basic science. By the time he gets to his junior year he is a thoroughly frustrated individual with a feeling that he hasn't really learned his basic work and with no confidence in his technical abilities. He has become, in spite of himself, the world's best "Artful Dodger" and has picked up along the way a completely developed inferiority complex that he never loses.

Some four years ago we started an examination of this system in an effort to find out if possible where its weakness lay and to arrive at an explanation of the differences that were asserted to exist between medical and dental students. I believe you will be interested in some of the things we discovered.

First of all, we found that the average dental student was two years younger than the average medical student and therefore that much less mature. Second, he had been accepted with lower scholastic averages. Then we compared the work load of the two groups for the first two years and we received a real shock. We found that although the two groups were carrying practically the same load of premedical science the dental students were forced to devote all of their other time to the mastery of technics, while the medical students had this time completely free for study. In other words, we were expecting a younger student and one with lower preprofessional grades to carry a significantly heavier load and perform as well. It did not make sense. Our first step toward reform was to attempt to set our own dental house in order.

Since time immemorial technics had been taught by departments, the denture department teaching denture technic, the crown and bridge department, crown and bridge technic, and so forth. Each department head was requested to submit the answers to three questions: 1. What do you expect of a student when he goes into the clinic at the beginning of the junior year? 2. What phases of this preparation are the responsibility of your department? 3. How and what do you teach to attain your objectives? All this material was brought to the first meeting of the clinical departments and then began a six-month series of meetings devoted to a study of the purely dental phases of the curriculum.

The answers to the three questions revealed all too clearly that each department head expected a fully trained dentist before he had even seen a patient. Further it was quickly discovered that certain technics were being taught with only minor modifications by several departments while other technics were being completely neglected because each department assumed that another was teaching it. The absurdity of many things that were revealed was so apparent that the committee to a man wanted to do something about it. The plan evolved has been gradually put into effect.

Briefly what was done was to examine critically every technical procedure that was considered essential to preclinical training and to classify it according to the basic principles it involved. When this task was completed it was realized that all technical procedures could be placed under one of four headings: (1) the cold fashioning of metals such as filing, sawing, swaging, burnishing, piercing, and graving; (2) the hot fashioning of metals, soldering, and casting; (3) the handling of plastic materials such as plaster and cement which result in crystal formation, and the non-crystalline group such as compound, hydrocolloid, alginate, and acrylic, and (4) the cutting of tooth structure.

A course labelled Basic Technics was laid out and the freshman students were introduced to one technic at a time. Each session was proceeded by a quiz on the material and instruments to be handled and based on a reading assignment in a manual developed by the staff. Beginning with a pure filing exercise and progressing through technics and procedures of increasing difficulty, the class was casting by the vacuum method before the quarter was two-thirds over. They had the upper classmen green with envy. And now we decided on a radical step.

For the remainder of the quarter the class was put into the clinic and, after only two demonstrations, the students began to take the plaster impressions of each other. After trying to teach this difficult technic to juniors and seniors, the results obtained by the freshman amazed us. But more enlightening was their response. They displayed none of the fear that had been so apparent in the upper classes and they thoroughly enjoyed the work.

It is not the intent of this talk to defend a particular course of technical training but rather to indicate certain factors—primarily of a psychological nature—that we had been neglecting. At the beginning of our experiment our chief concern had been to cut down the time devoted to this phase of dental education without losing quality. We believed that this would leave more time for basic science preparation. Since the course had been laid out and conducted by a joint staff composed of men from all departments, we were confident that none would be slighted and that there would be no overlapping of instruction. We underestimated the capacity of the student—if we thought of it at all. At the end of the first year we had reduced by almost twenty per cent the time formerly devoted by the various departments to dental technics and materials and had better utilized the remaining hours. This encouraged us to take another step.

There is probably no greater frustration than that caused by having too much to do and not time enough to do it properly. And when one's efforts have to be directed in a variety of fields the condition is aggravated. This has always been the plight of the dental student, at least at the University of Illinois. Forced to carry an array of science courses, he had his attention further diverted by the demands of a whole battery of technical courses. The combining of the technical courses had eliminated one source of irritation so that the student could concentrate his attention on one course at a time, but it was felt that he was still overloaded. We next turned to the sciences.

A meeting was called of all department heads responsible for the teaching of the medical sciences and the plight of the dental student was carefully explained to them. When they were told that during his first two years a younger student was being required to carry many more clock hours than an older student, they were impressed with the impossibility of a good performance and were anxious to correct the situation. I am sure they expected that the request would be for a lighter load for the dental student but this was not our intention. We merely asked that the load be redistributed in such a way that the dental student would carry only two sciences, at any one time. To this they readily agreed since it would not require any rearrangement of courses on their part, although some of them were frankly skeptical that the plan would work.

This skepticism was based on the fact that we were ignoring a dearly held tenet of most educators; namely, a strict ordering of the sequence of courses. It is apparent that arithmetic has to precede algebra and one could quote other examples of a similar dependence in the exact sciences. This concept has taken complete hold of educators in other fields and each attempts to place theoretical courses in what is called a logical order. The student cannot possibly study a given subject until he has studied the prerequisite courses. But early in our experiment, before the science departments were asked to cooperate, we had been forced to take a chance with the disturbance of sequence. It was necessary to give one class its course in physiology of the nervous system before it had taken neuroanatomy. Much to the surprise of all, this class scored as well as those that had been previously conditioned.

To give a concrete idea of the manner in which our curriculum has been altered I should like to outline it as it has been offered to our freshman class. During the first quarter this class took physiological chemistry and general histology. The latter was for the sole purpose of acquainting the student with the structure of tissues he would be studying in other courses. During the second quarter he continued his chemistry but dropped histology for gross anatomy. During the third quarter, having finished his chemistry, he started physiology and continued anatomy. Both of these courses will continue through the first quarter of the second year and in addition the student will take a course in neuroanatomy. This is the only quarter in which he has three science courses. Although the neuroanatomy is a demonstration course and requires compara-

tively few class hours, it has always been a terrible bugbear for both the medical and dental student. The work in anatomy during this quarter is head and neck, and in physiology the study of the nervous system. Hence the student will be studying neurology from three aspects simultaneously, and we think that this advantage should more than make up for the few additional clock hours and result in better preparation.

With the end of this quarter the student will have finished his year of anatomy but physiology extends for one more quarter during which he will go back to histology, this time to review general histology and to study the dental tissues. Histology extends through two quarters. Bacteriology begins after physiology ends and continues through the first quarter of the junior year. The student will study no pathology until the third year and no oral pathology until the third quarter of that year. During the entire fourth year he will carry a major in oral medicine.

Now for just a moment let us return to a consideration of the purely dental side of the student's training. We left him, you will remember, taking plaster impressions of his classmates at the end of the first quarter of the first year.

Beginning the second quarter the laboratory periods were devoted to an application of some of the technics the student had learned by introducing him to prosthetic procedures in the laboratory. After only a short period of training in such details as mounting casts, preparing base plates, bite-rims, and setting up teeth, he was assigned an edentulous patient and started true clinical work. And again his instructors were amazed because his performance was fully equal to or better than that of former junior students. At the same time, after preliminary lectures and demonstrations, he was back in the clinic cleaning his classmate's teeth, charting his mouth, and beginning to read x-rays. In the laboratory he was applying basic technics to the construction of various types of partial dentures. This completed his freshman year.

I shall not carry the description of his training further except to point out that the student does no cutting of dental tissues until he is a sophomore and he devotes much of this year to it. Toward the end of the year he starts his crown and bridge training which may continue into the junior year if necessary.

The objectives sought in this curriculum might be stated to be: 1. A more gradual development of the student's knowledge and background on the one hand and of his technical skill on the other. 2. A more even distribution of technical, clinical, and theoretical loads over the four years. 3. Better motivation toward learning by giving him early clinical experience. 4. Better-rounded courses through the cooperative efforts of all departments.

If the objection be raised that we have the cart before the horse and that we are being illogical in not giving all the basic science courses before we permit patient management, it should be pointed out that we are attacking this problem in the manner in which man has always solved his problems. He has proceeded from empiricism toward science. Experience first arouses his curiosity and then he tries to satisfy that curiosity. As he grows older he tends to forget this and he says to the young man, "do not do it the way I did it—do it the way I say to do it," never realizing that logic cannot of itself take the place of the motivation of curiosity.

Now since this is above all a scientific society I wish to point out that our experiment—although promising of results at present—is not controlled. In fact, I think it is safe to say that we are dealing with a loaded sample because our postwar classes are more mature and superior in scholarship. They would probably have performed better under the previous curriculum than classes that had gone before. Nevertheless, we think we detect an enthusiasm for dentistry

and even for its preparation that has been lacking in the past and we are confident that the experimenter is going to learn something even if the guinea pig doesn't.

It is time that dentistry learned that it cannot be dependent on medicine indefinitely—even for its examples. There are uneasy stirrings in medical education also and if changes come about, dentistry must be prepared to say something besides, "Me too," as it has so frequently done in the past. Our experience thus far leads us to believe that dental education lends itself to experimentation much more readily than does medical education. We shall be very foolish if, through adherence to a mass of traditions of questionable validity, we miss the opportunity to develop a program more suitable to our own needs.

II. Index of Participants, and Sequence Numerals of Corresponding Abstracts

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III. First General Session: Section IA; Friday Evening, June 18; Abstracts 1-12

1. Effectiveness of various topical procedures using sodium fluoride and kindred agents. *B. G. Bibby, W. D. Wellock, F. Roberts, E. Khenkenberg, Esther Wilkins, and R. Davenport, Tufts College Dental School, Dental Division, Mass. Dept. of Public Health, Boston, Mass.* Studies on the effectiveness of various methods of using sodium fluoride and kindred agents for the control of dental caries have been carried out. These include one-year clinical studies employing sodium fluoride as an acidulated mouthwash, as a pumice-peroxide prophylactic paste, as topical applications in an adult group, as lozenges and coated pills, and in a water supply. The results of topical applications of an acidulated lead fluoride solution, a neutral lead fluoride solution, and an indium nitrate solution are also reported. To conform with current standards of scientific criticism, a study using a commercial calcium fluoride lozenge was assessed by means of repeated lactobacillus counts rather than by clinical examinations.

2. A preliminary report on the fluoride content of normal blood and urine as related to the fluoride content of community water supplies. *Frank A. Smith and Dwight Gardner, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* A new procedure has been developed for the determination of fluoride in blood. Using this new procedure, together with previously existing procedures for the analysis of urine samples, the fluoride content has been determined for blood and urine samples collected in communities where water supplies contain widely varying amounts of fluoride.

3. The Evanston dental caries study: III. A preliminary study of the distribution of fluorine* in communal water supplies in the United States. *I. N. Hill, D.D.S., O. E. Jelinek, D.D.S., and J. R. Blayney, M.S., D.D.S., Evanston Health Department and Zoller Clinic, University of Illinois, Evanston and Chicago, Ill.* This study was made to determine the areas in the United States where fluorine occurs naturally in the communal water supplies, and the number of people having access to those water supplies. The records of fluorine determinations were obtained from the Chief Sanitary Engineers of the Health Departments of forty-eight states and the District of Columbia. A total of 5,642,887 people in the United States have access to communal waters containing fluorine in a concentration ranging from 0.5 parts per million or more. This is

*Fluorine as used in this paper refers to the combined form, probably calcium fluoride or sodium fluorides; when expressed as parts per million, it refers to the element fluorine.

approximately 4.30 per cent of the entire population. The number of people in this country having access to water containing fluorine is shown in Table I.

TABLE I

PLACES WITH FLUORINE PRESENT NATURALLY IN THE COMMUNAL DRINKING WATER SUPPLY

Fluorine concentration in P.P.M.	0.5-08	0.9-2.0	2.1-3	3.1-5	5.1-Up
Population	2,658,211	2,195,115	626,177	123,296	40,090

4. STABILITY OF AQUEOUS SOLUTIONS OF SODIUM FLUORIDE. *William Savchuck, D.D.S., and W. D. Armstrong, Ph.D., M.D., Schools of Medicine and Dentistry, University of Minnesota, Minneapolis, Minn.* Solutions of sodium fluoride as employed in topical applications to teeth were stored for six months under varying conditions in soft glass bottles and in Pyrex bottles. Those solutions stored in Pyrex were more stable than those stored in soft glass bottles.

5. IONIC EXCHANGE AS THE MECHANISM FOR Ca_{45} ADSORPTION BY BONE, DENTIN, AND ENAMEL. *Elizabeth K. Emery, H. C. Hodge, and M. Falkenheim, The University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Powdered bone, dentin, and enamel have been exposed to calcium$_{45}$ *in vitro*. Each tissue was found to adsorb Ca_{45} according to a somewhat complicated course of reaction. There was a rapid phase of adsorption lasting perhaps four hours. This rapid adsorption is succeeded by a much slower process which appears to be increasing slowly and steadily even after 10-day exposures to the solution. It is possible to calculate the percentage of calcium which enters into an exchange reaction with solution calcium. This exchange fraction of the bone is of the order of 20 per cent, similar in magnitude to the fraction found in the phosphate experiments. The adsorbed Ca_{45} may be desorbed in a fashion which strongly indicates the reversibility of the exchange process.

6. HISTOCHEMICAL STUDY OF ALKALINE PHOSPHATASE IN TEETH AND BONES OF HYPOPHYSECTOMIZED AND OF RACHITIC RATS. *Anna Morse and R. O. Greep, School of Dental Medicine, Harvard University, Boston, Mass.* Using a standardized new technic for demonstrating alkaline phosphatase after decalcification, we have studied the localization and semiquantitative distribution of the enzyme in the tibias and incisors of young rats in which growth had been distributed by feeding rachitogenic diet or by hypophysectomy. Phosphatase in the latter animals showed a distinct over-all reduction in concentration with some effect upon localization; pair-fed controls showed less marked reduction. Phosphatase persisted in high concentrations in teeth and bones of rachitic animals. Hypophysectomy is well known to interrupt both matrix formation and mineral deposition in bones but not in the incisors; rickets disturbs only the mineralization. The phosphatase distribution pattern under these conditions may aid in the difficult task of elucidating the metabolic role of this enzyme.

7. THE INCORPORATION OF RADIOACTIVE CARBON IN THE SKELETON AND TEETH OF RATS. *W. D. Armstrong, Jack Schubert and Arthur Lindenbaum, Schools of Medicine and Dentistry, University of Minnesota, Minneapolis, Minn.* The administration of radioactive carbon as sodium carbonate and as calcium carbonate results in the incorporation of the radioactive carbon in the mineral phase and in the protein of bones and teeth.

8. DETERMINATION OF PROTECTED AND UNPROTECTED ENAMEL, DENTIN AND TRICALCIUMPHOSPHATE SOLUBILITY BY MEASURING FILTRATE CALCIUM AND PHOSPHORUS. *Joseph C. Muhler, B.S., Thomas M. Boyd, A.B., and Grant Van Huysen, D.D.S., Indiana University School of Dentistry, Indianapolis, Ind.* One hundred forty-five reagents were appraised for their ability to reduce the solu-

bility of enamel, dentin, and tricalciumphosphate. The method of evaluation was by determination of normal unprotected solubility of the two tissues and tricalciumphosphate by decalcification with .2M CH_3COOH and comparing this data with that obtained by treating protected (protected with reagent solution) enamel, dentin, and tricalciumphosphate with similar aliquots of .2M CH_3COOH. Results indicate that enamel is most resistant to decalcification with dentin and tricalciumphosphate following in the order listed. Various reagents not containing fluorine have the ability to reduce the solubility of enamel, dentin, and tricalciumphosphate. The most satisfactory reagent used to decrease the solubility of enamel, dentin, and tricalciumphosphate in vitro is stannous fluoride.

9. Correlation of blood glucose tolerance and tissue glycogen concentration in periodontal disease. *C. A. Ostrom, Cdr., DC, USN, J. L. Switzer, M.D., and L. S. Fosdick, The Clinics and Laboratories, Northwestern University Dental School, Chicago, Ill.* Recent evidence suggests that periodontal disease may be basically a putrefactive process. In view of the fact that bacteria and higher organisms prefer to utilize carbohydrates for energy metabolism, it was thought that some correlation between the condition of the gum tissue and the glycogen content might be found. Decreased phosphatase activity and decreased glycogen concentration in the gingival tissues in cases of both periodontoclasia and traumatized tissue have been reported. The etiology of this failure of adequate glycogen for fuel might be either one of failure of the mechanisms which convert blood glucose to tissue glycogen or factors which destroy the tissue glycogen before it can serve its function. The blood glucose is the source of tissue glycogen. The blood glucose level at any static point indicates the balance between production of glucose by the liver and utilization by the tissues. From this premise, it follows that if periodontal disease is a result of systemic dysfunction of carbohydrate metabolism, then the altered tissue glycogen concentration should be associated with altered blood glucose tolerance. In this study, comparison of tissue glycogen concentration and blood glucose tolerance is made between patients with periodontoclasia and patients who show optimum health of the dental supporting tissues.

10. The efficiency of brushing the teeth. *W. E. Ludwick, Cdr., DC, USN, and L. S. Fosdick, U. S. Naval Training Center, and Chemistry Department, Northwestern University Dental School, Great Lakes and Chicago, Ill.* It has been suggested that the plaques or debris covering the teeth may have a relatively high concentration of ammonia, particularly in immune individuals. In so far as permutit is a fine abrasive powder and will absorb the ammonia it comes in contact with, it was thought that if the tooth brushings in any individual were quite constant in regard to the ammonia content, a method could be devised whereby the cleansing efficiency of brushing the teeth could be determined. For this purpose the teeth were brushed immediately upon arising on successive days using a definite technic for a definite period of time. It was found that the day-to-day variation in ammonium content in most cases was quite small, the range of deviation being from 2 to 30 per cent. In so far as the daily variations in the ammonium content of the tooth brushings from most individuals were quite constant, it was thought that this could be used as a measure of the amount of debris removed by brushing. After determining the daily variations in the ammonium content of brushings, the teeth were then given a thorough prophylaxis by means of instruments after the teeth were brushed with permutit. All debris that was removed from the tooth surface was then placed with the permutit that had been used for brushing the teeth and the total quantity of ammonia determined. The difference between the total quantity of ammonia produced by brushing and prophylaxis and that contained in the tooth brushings was used as a criterion of the amount of cleansing that could be

secured by brushing the teeth. It was found there was a large deviation in the relative amounts of ammonia removed from the tooth surface from individual to individual, and that if this is a criterion of the cleansing efficiency by means of brushing, the efficiency would vary between 40 and 98 per cent.

11. CHEMICAL NATURE OF HUMAN ENAMEL PROTEIN. *F. L. Losee and W. C. Hess, U. S. Naval Dental School and Georgetown University Medical and Dental Schools, Bethesda, Md., and Washington, D. C.* Precise definitions of human tooth enamel and its component parts are given. Qualitative determinations are made of the organic-inorganic proportions present in enamel by use of four basic methods. Lack of uniformity in results of some earlier investigators is explained. Protein content of the organic component is estimated by the determination of the total nitrogen. A method is described for obtaining and hydrolysing this protein. Methods are described for determination of four amino acids. It is shown that the protein of the enamel cuticle differs from the protein in the enamel proper.

12. STUDIES ON THE EFFECT OF DL-GLYCERIC ALDEHYDE ON THE DENTAL CARIES ACTIVITY IN WHITE RATS AND COTTON RATS. *James H. Shaw, Harvard School of Dental Medicine, Boston, Mass.* The observations of Fosdick and Calandra (*J. D. Res.* **26**: 309, 1947), that dl-glyceric aldehyde had a strong inhibiting action on the acid formation in incubated saliva suggested testing this material as a caries-inhibiting agent in experimental animals. The basal caries-producing ration used in these studies was that described by Shaw (*J. D. Res.* **26**: 47, 1947). In the first experiment, 43 white rats were divided into four groups. For the entire fourteen weeks of the experimental period, rats in the first group received the basal ration; those in the second group received a 0.5 per cent supplement of dl-glyceric aldehyde; and those in the third and fourth groups were given a 1 per cent and 2 per cent supplement respectively. In the second experiment, 19 cotton rats were divided into four groups which received the same supplements for the first nine weeks as in respective groups in the white rat experiment; for the remaining five weeks the animals in all three experimental groups received a supplement of only 0.5 per cent dl-glyceric aldehyde. No caries-inhibiting effect of the dl-glyceric aldehyde was observed, as judged by the average number of carious teeth per animal, the average number of carious lesions per animal, and the average extent of the carious lesions per animal. The rate of growth of all animals receiving the 1 per cent and 2 per cent supplements of dl-glyceric aldehyde was markedly lower than that of the animals receiving the 0.5 per cent supplement or the basal ration. No appreciable difference in growth was observed between the animals receiving the 0.5 per cent supplement of dl-glyceric aldehyde and those receiving only the basal ration.

IV. FIRST SESSION: SECTION IB; EVENING; JUNE 18; ABSTRACTS 13-22

13. A PRELIMINARY STUDY OF THE EFFICIENCY OF METYCAINE AS A LOCAL ANESTHETIC IN DENTAL SURGERY. *Emmett R. Costich, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Metycaine hydrochloride plus adrenalin 1:60,000 was compared with procaine hydrochloride plus adrenalin 1:50,000. A group of 53 patients received 99 injections (57 metycaine, 42 procaine). All injections, observations, and surgical procedures were carried out by one individual. The syringes were filled by another person and the anesthetic solutions used were unknown to the operator until the completion of the study. Records were kept of age, sex, pulse rate, blood pressure, respiration, systemic reactions, type of injections, post-operative course, et cetera. No significant differences between the effects of the two solutions were noted except that the metycaine produced anesthesia for from 2 to 3 hours in the major portion of cases as compared to 1 to 1½ hours for procaine.

14. CLINICAL STUDIES IN THE DEVELOPMENT OF THE DENTAL HEIGHT. *M. Michael Cohen, D.M.D., Tufts College Dental School, Boston, Mass.* Growth and development of maxilla and mandible and development of dental height in ectodermal dysplasia, pituitary dwarfism, and in two normal individuals who had congenitally absent teeth were studied. All have had annual radiographs and impressions when possible. One ectodermal dysplasia case first seen at age 6 years had complete anodontia. Casts at this time showed edentulous maxilla and mandible which compared favorably in size with those of a dentally normal child of same chronological age. Casts made two years later (age 8) revealed increase in size in both jaws which corresponded to jaws with full complements of teeth in children of this age. The second case of ectodermal dysplasia was first seen at age 2 years and 9 months and was followed annually with x-rays and impressions for 5 years. When first casts were made, patient was 3 years of age and had only 12 teeth. Her series of casts showed annual increase in size of maxilla, and mandible showed prognathism which could be accounted for genetically since both her mother and grandmother were prognathic. Two cases of pituitary dwarfism were observed from ages 2 years and 9 months to 8 years and 3 months and from 15 years and 5 months to 20 years. Osseous development in maxilla was not as greatly retarded as in mandible. Lack of ramus length in these two cases caused inhibited growth of intermaxillary space and failure of increase in vertical dimension of maxilla and body of mandible. Two normal individuals with congenitally absent teeth showed normal development of both maxilla and mandible and no interference with ramus growth. The dental height developed since there was no effect on the general osseous development in these children, showing that the growth of jaws and intermaxillary height developed independently of the teeth.

15. CLINICAL DIAGNOSIS AND TREATMENT OF TEMPOROMANDIBULAR DISTURBANCES. *George A. Hughes, D.D.S., College of Dentistry, University of California, San Francisco, Calif.* Temporomandibular disturbances of dental origin are of frequent occurrence. The etiology of such conditions is often obscure, but in many cases can be traced to any one or a combination of the following causes: (1) acute traumatic factors, (2) chronic traumatic factors, (3) irritation or infection, (4) malocclusion, and (5) psychoneurosis. The types most frequently encountered in dental practice are due to trauma, missing teeth, or malocclusion. The use of latex splints has been found of great value in confirming the diagnosis of complex cases and in treatment of simple cases. Modification of vertical dimension posteriorly to relieve pressure on the temporomandibular joint in complete and partial denture cases is made by applying pressure at the posterior after the setup has been completed.

16. ANTEROPOSTERIOR DYSPLASIA IN YOUNG ADULT MALES. *Wendell L. Wylie, D.D.S., M.S., and Norman S. Snyder, D.D.S., College of Dentistry, University of California, San Francisco, Calif.* Wylie and Elsasser have shown that dysplasia in the anteroposterior plane of the human head provides the fundamental basis for departures from correct mesiodistal relationships of the posterior teeth. This report applies similar methods to a group of young adult males, to provide norms for this age range, and to differentiate quantitatively between "good," "average," and "poor" facial patterns as appraised from oriented facial photographs.

17. EFFECT OF SEVERE CALCIUM-PHOSPHORUS DIETARY RATIOS AND REPEATED PREGNANCY AND LACTATION ON THE INORGANIC CONTENT OF RAT TEETH. *Paul C. Kitchin, T. S. Sutton, and L. F. Edwards, Ohio State University, Columbus, Ohio.* It is generally conceded that developing teeth have a high priority for available Ca and P salts and that once having them they cannot be physiologically removed

from the teeth. This project was planned to test these points with more drastic conditions than have yet been used. Six groups of mature female rats, each group consisting of five rats, were used. Each group had one member of the five litters common to all groups. Two experimental factors were involved: (1) Ca and P content of the diet and (2) repeated pregnancies and lactation periods. Determinations were made of individual bone ash per cents and of pooled samples of incisor and molar dentin and enamel ash per cents. On the basis of results from micro-balance determinations, there are indications that a diet deficient in Ca and P and with a ratio of 1 to 13, coupled with repeated successive pregnancies and lactation periods, may result in a decreased inorganic content of the dentin of both incisors and molars and a decreased inorganic content of the enamel of incisor teeth.

18. Cleft upper lateral or early fusion of two tooth germs (formerly dens in dente). *B. Gottlieb, Baylor University, College of Dentistry, Dallas, Texas.* The first reference to this problem was made in 1859 by John Tomes in his *System of Dental Surgery*. Until now the literature reports four upper first incisors, five upper canines and thirty-two upper second incisors (including eleven observations of the author). The finding can be characterized as showing enamel inside the crown. The following explanation is offered. The beginning of the formation of the tooth germ of the upper second incisor appears while the frontal process has not yet fused with the maxillary processes. Fusion soon occurs and a single tooth develops in the normal location of the upper second incisor. However, if both components degenerate, the second incisor may be entirely absent. If both continue to develop a tooth independently, two second incisors will be formed. In those cases in which we find two bands of enamel in the center of the crown, it is probable that both halves started independent development and then merged into a common tooth. The dividing line between the two bands of enamel is thus a division between the two separately originated laterals. While in most instances the cleft goes through the second incisor, in rarer cases it may go through the first incisors and distally as far as between the canine and the first premolar. That explains the range of the findings in the region of the premaxilla. Recently a similar finding could be made in a mandibular first premolar. As far as the literature could be checked it represents the first observed case outside the region of the premaxilla. The x-ray indicates that two germs had fused in an early stage of development and continued to develop in their twin position. The one was apparently a supernumerary tooth. Here as well as in most reported cases in the upper anterior region, the pulp was necrotic. It seems probable that the pulp tissue does not tolerate contact with enamel, being damaged by that contact to the degree of necrosis.

19. Changes in the temporomandibular condyle of the rat resulting from endocrine disturbances, produced by hypophysectomy, throidectomy, and injections of pure pituitary growth hormone and thyroxin. *H. Becks, D. A. Collins, M. E. Simpson, and H. M. Evans, University of California, San Francisco, Calif.* The temporomandibular articulation which is of such profound importance to the dentist has found very little attention in the past from the standpoint of structural changes produced by general factors influencing growth and development. For this reason, a large-scale histologic investigation was undertaken to study the effect of hypophysectomy, thyroidectomy, and injections of pure pituitary growth hormone and thyroxin on the mandibular condyle of the rat (Long-Evans strain). Removal of the pituitary gland at 28 days of age resulted in an early maturation. Thirty days after the operation, the maturation

had reached a stage comparable to that of a 258-day-old normal. Thyroidectomy at birth retarded maturation. The cartilage retained its juvenile characteristics while the neck and ramus completely ossified. Several hundred days following hypophysectomy, the injection of the pure anterior pituitary growth hormone reactivated chondrogenesis and osteogenesis comparable to that seen in a 20-day-old normal. Thyroxin had little or no effect. A combination of growth hormone and thyroxin produced a reactivation of both processes, but the response was less than with growth hormone injections alone. This lack of synergism is in contrast to that observed in the proximal epiphyseal disc of the tibia. Chronic growth hormone injections in adult normal rats produced new growth resulting in a larger distorted condyle although injections were begun after complete ossification of the condyle. Growth hormone injection begun twelve days after hypophysectomy maintained growth in the condyle long after maturation should have occurred.

20. DENTIO PRAECOX. *B. E. Rynearson, J. L. Langohr, and O. A. Brines, Detroit University, Receiving Hospital, Wayne University, Detroit, Mich.* The study of the jaws of a 7-month fetus was reported. Uncalcified transverse segmentation of the ridge mucosa which simulated in size and shape the primary teeth was found.

21. THE CONDITION OF THE YOUNG DENTAL PULP FOLLOWING THE FIVE-MINUTE APPLICATION OF SODIUM FLUORIDE TO DENTIN. *Gordon H. Rovelstad, D.D.S., and William E. St. John, D.D.S., School of Dentistry, Northwestern University, Chicago, Ill.* The purpose of this study was to determine the condition of the young dental pulp following the desensitization of freshly cut dentin in young premolar teeth. Fifty-one young premolars were included in this study of which eleven were used as control specimens. There is some evidence in this study that the young dental pulp will exhibit histological changes following the cavity preparation and desensitization (five-minute application) with sodium fluoride. These changes appear to differ from the changes that occur as a result of cavity preparation alone.

22. THE ACCURACY AND PRACTICAL VALUE OF INTRA-ORAL RECORDS OF CONDYLE PATH INCLINATION. *F. W. Craddock, School of Dentistry, Northwestern University, Chicago, Ill.* An experimental clinical investigation was made into the reliability and validity of the Christensen method of recording condyle path inclination by means of wax records of protrusive jaw relations. This procedure, which is widely used by prosthetists for adjusting condylar guidance on articulators, is shown to be unreliable and hence of doubtful practical utility. An alternative radiographic method was described, and the general influence of condylar guidance on the occlusal relations of teeth in functional contact as they are studied in prosthetics, orthodontics, and periodontia discussed.

V. SECOND SESSION: SECTION IIA; MORNING; JUNE 19; ABSTRACTS 23-33

23. THE EFFECT OF X-RAYS ON THE RAT INCISOR. *Peter P. Dale, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Five groups of 30 weanling and 30 adult rats of equal sex distribution were exposed to single, whole-body exposures of 0, 375, 500, 625, and 750 roentgens (r) administered under constant conditions of 250 K.V.; 15 M.A.; Al parabolic filter and ½ mm.Cu; H.V.L. 2.1 mm.Cu, and 44 minutes time. Thirty days after exposure, the survivors were sacrificed and the teeth of all animals were examined grossly and eight animals per group were studied histologically by means of ground and decalcified sections. Data disclosed a slightly greater mortality among males, with no apparent age difference: Controls—0; 375r—1 (adult female, otitis media); 500r—6 (3 ♂♂); 625—22 (16 ♂♂) and 750r—50 (28 ♂♂).

Gross examination (× 30) revealed increased periodontal disturbances (edematous and bleeding gingivae) and enamel hypoplasia as exposure increased. Histologically, there was temporary retardation or cessation of both enamel and dentin formation, with apparently normal recovery at the formative end of the incisor. At 375r the enamel was affected more than the dentin and was characterized by small, irregular, amorphic, and discolored enamel rods with dark inclusion bodies in the interprismatic substance.

24. RADIOGRAPHIC CHANGES IN DIABETES MELLITUS. *Maury Massler, D.D.S., M.S., and Saul S. Stahl, D.D.S., University of Illinois Hospital Dental Clinic, Chicago, Ill.* Thirty-four diabetic patients (12 males, 22 females, ages 14 to 55 years) were subjected to detailed clinical and roentgenographic study to determine whether specific periodontal changes could be related to the diabetic state. It was found that, in general, an increase in the severity of the diabetic state was associated to a significant degree with an increase in destructive changes in the alveolar bone (Coefficient of Association [Pearson] = 0.65). These changes were, however, nonspecific and consisted, variously, of alveolar bone atrophy, vertical and/or horizontal; interruptions of the lamina dura; decreased number of trabeculae; and root-end resorptions. A similar tendency was observed when the severity of gingivitis was related to the severity of the diabetic state (Coefficient of Association [Pearson] = 0.62). Specific periodontal changes could not be established as characteristic of the diabetic state. Although some relation exists between the severity of the diabetic state and the destructive changes in the alveolar bone and the gingiva, a cause and effect relation could not be established.

25. EFFECT OF ATOMIC RADIATION ON THE ORAL STRUCTURES. *Joseph L. Bernier, D.D.S., M.S., Army Institute of Pathology, Washington, D. C.* Extensive and rapid destruction of the peripheral leukocytes and lymphatic tissue accounts for the appearance of ragged, irregular ulcerations in the oral mucosa. These apparently result from the invasion of oral microorganisms following superficial abrasions with a rapid breakdown of the mucosal tissues. Such lesions occur following both lethal and sublethal doses of gamma radiation, and are consistent enough to be considered pathognomonic. The loss of peripheral defense cells accounts for not only the lesions described but also the occurrence of an ulcerative gingivitis.

26. ROENTGENOLOGIC EXAMINATIONS OF PERIAPICAL FIBROMA WITH REPORTS OF CASES. *Harrison M. Berry, Jr., School of Dentistry, University of Pennsylvania, Philadelphia, Pa.* Ossifying periapical fibroma occurs chiefly in women, and more often in negro than white women. Its most common site is at the apices of the mandibular incisors and canines; it is very infrequently found in the maxilla. The teeth with which it is associated respond normally to thermal and electrical vitality tests, color is normal, no pain or discomfort to percussion, and no clinical symptoms are present. Its presence can be detected only by means of the roentgenogram. In the early stages in which there is formation of a fibroma at the apex of the tooth, the roentgenogram reveals a radiolucent area. One of three courses may then be followed: 1. It may remain as a fibroma for an indefinite period. 2. It may calcify with cementum, resulting in the formation of a cementoma. 3. It may calcify with bone, so that ultimately only an area of finely trabeculated bone will be evident in the roentgenogram. In the early stages the differential diagnosis depends upon the vitality test, appearance, and history, plus the roentgenographic appearance of calcification within a circumscribed radiolucent area. Treatment consists of leaving it alone and following its course in the x-ray. A similarity has been noted between the common epulis and ossifying periapical fibroma, as both arise from the dental periosteum as fibromata, and both tend to calcify in the later stages.

27. CALCIUM: FLUORINE RATIO AND ACUTE AND CHRONIC FLUORINE TOXICOSIS AND DENTAL CARIES IN HAMSTERS AND RATS. *Kanwar L. Shourie, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* In thirty rats, intraperitoneal administration of appropriate amounts of calcium salts added to the lethal doses of sodium fluoride appeared to mitigate fluorine toxicity. In an experiment with a small number of animals administration of parathyroid extract to the experimental animals fourteen hours before the injection of lethal doses of sodium fluoride to the experimental and control animals protected most of the animals in the experimental group. Sodium fluoride toxicity studies have shown that younger animals (which probably have more available calcium due to active calcium metabolism) tolerate larger doses of sodium fluoride per kg. body weight. Addition of calcium ions to doses of sodium fluoride that produced mottling of teeth in rats of the control group protected against mottling in the experimental group. Fifty ppm. of fluorine as calcium fluoride in the diet did not prevent dental caries in hamsters. The calculated ratio of calcium to fluorine in the diets being used to produce caries in hamsters is very small. The Ca:F ratio in diets in India (where freedom from dental caries is reported to be higher than in the States) is lower than the Ca:F ratio found in diets being consumed in the United States.

28. EPITHELIAL CHANGES OF THE TONGUE IN RATS FED A PROTEIN DEFICIENT DIET. *Daniel E. Ziskin, D.D.S., Maxwell Karshan, Ph.D., and George Stein, M.D., D.D.S., Columbia University School of Dental and Oral Surgery of the Faculty of Medicine, New York, N. Y.* Ten immature albino rats (45 to 60 grams), five males and five females, were fed a synthetic diet complete in all respects but in which the casein was omitted as a source of protein. This experiment was in the nature of a pilot study for a more elaborate investigation of the influence of protein-deficient diets on the oral tissues. The animals refused to eat adequate amounts of the diet offered, but their appearance differed from that seen in inanition. They lost considerable hair and that which remained arranged itself in pointed tufts giving the animals a porcupine-like appearance. They were irritable and developed severe neurological symptoms which affected their gait. Terminally, some showed swellings on the face or torso which at autopsy proved to be amorphous, colorless, gelatinous masses. Their tongues appeared smooth and were bright red in color. Weight loss was progressive, the final weights being equal to those at weaning (35 to 40 grams). Histological examination of the tongues disclosed an alteration of the epithelium never before observed by us under experimental conditions. It consisted of a reduction in the thickness of the epithelium of the dorsum with replacement of the dermal and cornified papillae by smooth cornified epidermis so that the entire epithelial covering of the tongue resembled the epithelium normally found on the undersurface. This change, in varying degrees, was a consistent finding. In two cases, casein was added to the diet after marked clinical symptoms were manifest. Histological examination of the tongues showed the reappearance of the papillae.

29. EFFECTS OF FOREIGN BODIES UPON THE PERIODONTAL TISSUES OF THE GROUND SQUIRREL. *Neil H. F. Cheo, D.D.S., B.S.(Dent.), I. Schour, D.D.S., Ph.D., Sc.D., and J. P. Weinmann, M.D., College of Dentistry, University of Illinois, Chicago, Ill.* The study is based on microscopic investigations of the periodontal tissues of 422 premolar and molar teeth of 107 ground squirrels. The supporting tissues of 54 teeth (12.6 per cent) were found to be normal; 70 per cent of the teeth studied showed gingivitis and 16.8 showed periodontitis. The latter disease was found more frequently in animals which showed a deficiency in mineral metabolism characterized by a wide osteoid layer. In 162 instances the impaction of oat hairs could be seen in different tissues of the supporting

apparatus (gingival epithelium, lamina propria of the gingiva, periodontal membrane, bone marrow of the alveolar bone). In 206 instances of periodontal lesions, the presence of foreign bodies was not evident in the sections examined. The epithelium of the gingiva showed degeneration, coagulation, liquifactive necrosis or proliferation. The number of epithelial rests appeared to be increased in number. The connective tissue of the lamina propria of the gingiva, of the periodontal membrane, and of the bone marrow showed acute or chronic inflammation. The bone showed osteoclastic resorption and in advanced cases necrosis and formation of sequestra. Resorption of cementum sometimes progressed into the dentin. In far advanced cases necrosis of the pulp was also observed.

30. NUTRITIONAL REQUIREMENTS OF VARIOUS STRAINS OF LACTOBACILLI. *Thomas B. Coolidge and Ned B. Williams, Zoller Dental Clinic, University of Chicago, Chicago, Ill.* Nutritional and metabolic changes have been observed in oral lactobacilli accompanying changes in fermentation and antigenicity observed by Harrison, Williams, and others. Among these changes are changes in vitamin and amino acid requirements, acid production, and the pH attained in cultures. The facts are pertinent to the classification of lactobacilli, the pathogenicity of oral lactobacilli, and to the theories of mutation and adaptation in bacteria.

31. ANTAGONISMS OF MOUTH ORGANISMS. *Betty White, B.S., School of Dentistry, Western Reserve University, Cleveland, Ohio.* Because the oral flora changes to a predominance of gram negative organisms when large doses of penicillin are administered orally, it was desirable to know whether any of these organisms are primarily antagonistic to the growth of *L. acidophilus*. By means of broth cultures in wells separated from seeded agar plates by celloidin cups, *L. acidophilus* has been found to inhibit *A. aerogenes* and *E. coli*. While *A. aerogenes* filtrate does inhibit *L. acidophilus*, cultures of *A. aerogenes* and *E. coli* do not inhibit *L. acidophilus*. The amount of inhibition produced depends largely upon the production of a pH in the substrate more favorable to one organism than another.

32. PREVALENCE OF HEMOLYTIC STREPTOCOCCI ON THE GINGIVA AS COMPARED WITH THE THROAT: I. IN NORMAL YOUNG ADULTS. *Maury Massler, D.D.S., M.S., and John B. Macdonald, D.D.S., University of Illinois Hospital Dental Clinic, Chicago, Ill.* Although there have been many studies of the occurrence of beta hemolytic streptococci on the mucous membranes of the throat and nasal passages in both health and disease, little attention has been paid to these organisms in the oral cavity proper. The tonsillar fossae and labial gingivae of the lower anterior teeth of approximately 500 unselected medical and dental students were investigated for the occurrence of beta hemolytic streptococci, by means of swabbings from these areas cultured upon ordinary blood agar plates. It was found that the prevalence of beta hemolytic streptococci on the gingiva was approximately the same as upon the mucosa of the throat (6 per cent and 10 per cent respectively). However, the same person seldom (in only 30 per cent of the positive plates) showed positive cultures from both gingiva and throat at the same time.

33. PREVALENCE OF GINGIVITIS IN YOUNG ADULTS. *Isaac Schour, D.D.S., Ph.D., and Maury Massler, D.D.S., M.S., University of Illinois College of Dentistry, Chicago, Ill.* A quantitative method of assessing the prevalence of gingivitis in large groups of persons is proposed. Each gingival unit consisting of a papillary portion (P), a marginal portion (M), and an attached portion (A) is examined and counted separately. This method is tentatively termed the

P-M-A- Index (P-papillary gingivitis; M-marginal gingivitis; A-attached gingivitis). A detailed description of the method will be presented in a full report. The P-M-A Index was applied to 781 medical and dental students and 270 nurses, 20 to 34 years of age. It was found that an average of 2.4 gingival papillae and 1.1 gingival margins per person were affected by inflammations. Attached gingivitis was very rare (0.03 units per person). Within this group there was no significant increase in the amount of gingivitis with age nor was any significant difference observed between males and females. A surprisingly large number of persons (42.4 per cent) showed no clinical evidence of any gingivitis. Approximately 41.6 per cent showed a "mild" papillary gingivitis (1 to 4 papillae and 0 to 2 margins affected) while 10 per cent showed a "moderate" gingivitis (4 to 8 papillae and 2 to 4 margins affected). Only 6 per cent showed a "severe" gingivitis (more than 8 papillae and 4 margins affected).

VI. Third Session: Section IIIA, Afternoon; June 19; Abstracts 34-45

34. Some characteristics of caries on the proximal surfaces of the teeth. *John Haddin Barr, D.D.S., B.Sc.(Dent.), School of Dentistry, University of Texas, Houston, Tex.* In a study of 20,816 proximal surfaces of teeth from mixed and permanent dentitions, of which 9,018 showed evidence of carious attack, it was found that: 1. The pattern of proximal caries attacks on individual teeth displayed a striking measure of bilateral symmetry for the aggregate experience of whole groups of cases; but that this bilateral symmetry of the total proximal caries pattern was seldom encountered in individuals. 2. (a) There was high correlation between total maxillary and mandibular proximal carious incidence in posterior teeth of individuals. (b) In the presence of maxillary anterior proximal caries there was a significant correlation between its total frequency and that for all posterior surfaces in individuals. Absence of maxillary anterior proximal caries was not, however, associated with any particular level of posterior proximal caries. (c) Presence or absence of mandibular anterior proximal caries showed no significant inter-regional correlation. 3. Approximation of surfaces was obviously a factor in proximal caries incidence; and a consistently high percentage of proximal attacks occurred as adjacent pairs of approximated attacks. 4. No clear picture emerged related to age or sex factors. 5. There are important difficulties to be considered in selecting a basis for assessment of proximal surfaces as carious, under such circumstances as for example when teeth are missing or have been lost from the dentition. 6. By study of the total and incremental patterns of proximal carious attack it was possible to rank the various proximal surfaces according to their relative caries susceptibility. 7. Essentially similar patterns were characteristic of both slowly and rapidly developing carious attack on proximal surfaces of teeth. 8. Simple "spot" proximal fillings appeared to have become defective with five times the frequency of conventional occlusal-proximal two-surface restorations.

35. Changes in pigmentation of the fur of hamsters. *Kanwar L. Shourie and James K. Avery, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Three groups, 12 litter mate hamsters each, were fed the following diets ad libitum: Group A, caries-producing diet plus distilled water; Group B, same diet plus 50 ppm fluoride as NaF in distilled water; Group C, same diet plus whole liquid milk. Pigmentation changes were noted in the fur of Groups B and C. Group B animals were darker, and those of Group C were markedly lighter, as compared to Group A. Hemoglobin determinations of the blood of each animal revealed no significant differences among the three groups.

36. Acid production in saliva in-vitro experiments. *Thomas J. Hill, D.D.S., and B. White, B.S., School of Dentistry, Western Reserve University, Cleveland, Ohio.* In-vitro experiments with saliva do not simulate the rate of

acid production in the mouth. As sugar clearance in the mouth occurs in a relatively short time, the rate of acid production in saliva was studied for 90 minutes. Attempts to produce in in-vitro experiments rates of acid production comparable to that of the mouth could be made with a concentration of the residual matter of the saliva but could not be produced by increases in the number of lactobacilli. Acid production was entirely inhibited when filtered or highly centrifuged saliva was used even when large numbers of lactobacilli were added. These experiments indicate that some constituent of the saliva present in the residual matter after centrifugation or filtration acts as an agent in the rapidity of acid production.

37. AMMONIA CONTENT OF DENTAL PLAQUE IN RELATION TO DENTAL CARIES. *L. S. Fosdick and W. E. Ludwick, Cdr., DC, USN, Chemistry Department, Northwestern University Dental School and U. S. Naval Training Center, Chicago and Great Lakes, Ill.* It has been suggested that ammonium ion concentration in saliva is a major factor in determining susceptibility or immunity to dental caries. If ammonia is present in a concentration of fifty milliliters per one hundred cubic centimeter, the lactobacillus acidophilus ceases to grow. If the concentrations are a lower order of magnitude, then saliva can be made to support the growth of *Lactobacillus acidophilus*. In so far as saliva from either immune or susceptible mouths does not ordinarily contain the amounts of ammonia that would be necessary to inhibit the growth of *Lactobacillus acidophilus*, it was suggested by Kesel that perhaps the ammonia would be concentrated in the dental plaques. For this reason an attempt was made to determine the amount of ammonia in material removed from the teeth. In so far as one of the methods of removing debris from the tooth surface is by brushing the teeth, it was thought that comparative data could be obtained by analyzing tooth brushings for ammonia. It was found that instead of using an ordinary dentifrice, the brushing could be accomplished quite readily with permutit, which would serve the double purpose of absorbing all of the ammonium ions while in contact with the tooth surface. For this reason, tooth brushings using permutit as the dentifrice were analyzed. This procedure was repeated on saliva of one thousand individuals. The tooth brushings were collected immediately upon arising and the following day the salivary specimens were gathered for acidophilus counts. In addition to this, each individual was given a complete mouth examination, including bite wing x-rays and the caries activity was clinically estimated. The ammonia content of the brushings was correlated with the *L. acidophilus* count and with the clinical estimation of caries activity.

38. AN AUXANOGRAPHIC METHOD FOR THE DEMONSTRATION OF FACTORS WHICH MAY INFLUENCE DECALCIFICATION IN DENTAL CARIES. *Robert M. Stephan, Dental Research Section, Experimental Biology and Medicine Institute, National Institute of Health, Bethesda, Md.* At the present time little is known about the effects of dietary substances on the dental caries process except for carbohydrates and fluorides. An agar culture plate technic has been devised using the auxanographic principle of Beijerinck to demonstrate the effects of nutritional substances on the growth of oral microorganisms and their ability to produce acid and decalcification. This technic has been adapted for use with chemically defined media in which are precipitated calcium salts calculated to approximate the composition of calcium salts in teeth. Some of the factors which have been found to influence decalcification are: (1) the type of microorganism used, (2) the nutritional adequacy of the medium for growth of the specific microorganism used, (3) the composition of the calcified phase in the medium, (4) the kind and amount of carbohydrate employed, and (5) the presence of various trace substances which act specifically on certain microorganisms.

39. ALKALINE PHOSPHATASE AND AMELOGENESIS. *P. L. Johnson and G. Bevelander, College of Dentistry, New York University, New York, N. Y.* By histochemical methods, the localization and distribution of alkaline phosphatase was traced in ameloblasts throughout embryogenesis, histodifferentiation, matrix formation, and calcification. Contrary to negative findings reported in the literature concerning the presence of this enzyme in the ameloblasts, we find them essentially positive throughout their life history. In the preameloblast stage, while the nuclei are highly reactive, the cytoplasm is weakly positive. As differentiation proceeds, both the nuclei and cytoplasm become highly reactive including Tomes' processes, and remain so throughout matrix formation and calcification. Just prior to eruption the cytoplasm of the ameloblast becomes negative. Combined epithelium at all times is extremely positive as are the odontoblasts and pulp. Decalcified sections, using buffer solutions, likewise give essentially the same picture. Failure to maintain constant pH values and excessive paraffin temperatures cause negativity. Prolonged incubation does not enhance the positivity. Alkaline phosphatase in its distribution in time and location correlates well with the assigned functional activity of the ameloblast in the process of matrix formation and calcification.

40. THE RELATION BETWEEN DENTAL CARIES EXPERIENCE AND POLIOMYELITIS IN MINNEAPOLIS SCHOOL CHILDREN (1946 EPIDEMIC). *H. Berton McCauley, R. C. Likins, and Francis A. Arnold, Jr., Dental Research Section, Division of Physiology, Experimental Biology, and Medicine Institute, National Institute of Health, Bethesda, Md.* Examination of the teeth of 1,451 Minneapolis (Minn.) 5- to 15-year-old school children four to six months after the 1946 epidemic failed to reveal a relationship between dental caries and poliomyelitis. The examinees included 264 poliomyelitis cases, 464 household contacts, and 723 control children. Case, contact, and control groups were essentially alike in A—the number of carious, indicated for extraction, missing, and filled (DMF) permanent teeth per 100 children (343, 389, and 376 respectively); B—the number of carious, indicated for extraction, and filled (def) deciduous teeth per 100 children (366, 319, and 347); and C—the number of teeth having visibly exposed pulps or existing as residual roots per 100 children (20, 30, and 21). The results do not support the hypothesis that the dental pulp might constitute an important portal of entry for the virus of poliomyelitis in children.

41. EFFECT OF HIGH SUCROSE INTAKE ON CARIES DURING HYPOGLYCEMIC THERAPY. *Sholom Pearlman, D.D.S., William G. Sprague, B.S., D.D.S., and Ralph C. Best, D.D.S., Western Reserve University and Cleveland State Hospital, Cleveland, Ohio.* Mental patients undergoing insulin hypoglycemia therapy are customarily aroused from the comatose state by administration of strong sucrose solutions by mouth or lavage tube, or by intravenous glucose injections. Oral and dental examinations were made before and after treatment, and weekly acidophilus counts were made before, during, and after the treatment period. The effects of the use of these sucrose solutions are shown.

42. CORRELATION OF LACTOBACILLUS COUNTS WITH CARIES EXTENT IN AN INSTITUTIONAL POPULATION. *Julian D. Boyd, M.D., Virgil D. Cheyne, D.D.S., Ph.D., Kenneth E. Wessels, D.D.S., Department of Pediatrics, College of Medicine, and Department of Pedodontia, College of Dentistry, State University of Iowa, Iowa City, Iowa.* Lactobacillus counts from the saliva of more than 200 institutionalized children have been made in a state laboratory by personnel specially trained to provide such service to the dentists of the state. Duplicate analyses of samples collected within 24 to 48 hours were made for most subjects. All samples were collected before breakfast, after chewing paraffin. The individual

lactobacillus counts were correlated with the extent of tooth decay (DMF surfaces), the rate of progression of tooth decay during the previous 9 to 21 months, and the status of mouth hygiene. No correlation was evident except with the habitual and the current state of oral hygiene. The data offer nothing to support the premise that lactobacillus counts provide a diagnostic or prognostic index of the activity of dental caries. Any apparent relationship evidently relates to the hygiene of the oral cavity and the areas for lodgment of pabulum for bacterial growth rather than to the process of caries in itself.

43. DENTAL CARIES PREVENTION SERVICE. *H. Becks and A. Jensen, College of Dentistry, University of California, San Francisco, Calif.* A practical dental caries prevention service is suggested which has been tested in 1542 one-year observations on rampant dental caries over a period of 10 years. This prevention service has been conducted by individual consultation and consists of a reduction of excessive refined carbohydrates and their substitution by proteins and other carbohydrates. With this reduction, the vast majority of high *Lactobacillus acidophilus* indices which accompanied these rampant dental caries cases dropped drastically to a zero or low index in approximately 90 per cent of 752 one-year observations. Therefore, only 10 per cent failed to respond. Of these, 90 per cent who responded to nutritional correction as judged by the *Lactobacillus acidophilus* index, a total of 678 or 85.7 per cent were caries free in the subsequent year. Eighty-nine or 14 per cent developed one to two cavities, seven or 1 per cent developed three to five cavities, and only one patient developed six to nine cavities. A comparison of the results reported in 1944 and those contained in this survey reveals a decided improvement in the effectiveness of this prevention program. This is due largely to the improved technic and added experience of the counselors in handling such a highly individualized problem. A control group of 347 rampant dental caries cases was similarly treated as to repair but did not receive nutritional counsel. They also had high *Lactobacillus acidophilus* indices before repair was started and retained high *Lactobacillus acidophilus* indices in 321 or 92.5 per cent of the cases. Of these none were free from tooth decay. Two hundred and ninety-three or 91 per cent developed one to two cavities, twenty-five or 8 per cent developed three to five cavities, three developed six to nine cavities. This indicates that if the *Lactobacillus acidophilus* index is not controlled, caries activity will consistently continue even though the number of surfaces available for attack is greatly reduced. Since this suggested method has been tested on individuals suffering from the most extreme degree of dental caries with such a high percentage of favorable results, it is recommended that in the hands of experienced counselors, this approach offers at present the most effective means of combating this disease.

44. A METHOD OF ELIMINATING GINGIVAL PIGMENTATION. *Isador Hirschfeld, D.D.S., and Leonard Hirschfeld, A.B., D.D.S., Faculty of Dentistry, Columbia, University, New York, N. Y.* Clinical observations on results, several years after cauterization of pigmented gingival areas, in a small number of white or Negro patients. Some of the outstanding features are: (a) the continued absence of discoloration, (b) its return in certain parts and continued absence in other areas in the same individual, (c) the completely altered pattern and dimensions of the returned pigmentations, (d) the appearance of new pigmentation areas not formerly present, (e) a possible relationship between heavy smoking and pigmentations in some individuals.

45. FACIAL GROWTH IN ABNORMAL MUSCLE TENSION. *J. R. Jarabak, Dental School, Northwestern University, Chicago, Ill.* The components of mandible, the angles and the bicondylar width of two hundred skulls were studied. In a pre-

vious report the findings relative to body length and the ramus width were given. The mandibular angle, the bicondylar width, and the ratio of these to ramus height and body length will be reported in this paper. It was observed that there is very little or no relationship between bicondylar width and the mandibular angle, in other words, the acuity or lack of acuity of the mandibular angle cannot be associated with narrow or broad faces. The study of the mandibular angle disclosed the following facts: (a) The mandibular angle of the right and left side may vary as much as 10° and the denture may still be in normal occlusion. (b) The mandibular angle variation of from 2 to 4° may exist without any difference in either body length or ramus length from right to left side. (c) Where the angle difference is greater than 4° the body of the mandible may be longer and the ramus shorter or vice versa; or the bodies of the right and left side may be the same and the ramus of one side may be shorter or longer. In a number of instances in the said angular variations, it was observed that the plane of occlusion seemed either higher or lower depending on acuity of the angle; this fact was finally established by the use of the cartesian coordinate craniometer. The ratio of bicondylar width to body length shows that 77 per cent of all of the mandibles fall within the numerical average plus or minus the mean deviation. The same is true for ratio of bicondylar width to ramus height.

VII. Fourth Session: Section IVA; Evening; June 19; Abstracts 46-56

46. Studies on salivary mucopolysaccharides. *Norman S. Simmons, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* As part of the study of the salivary polysaccharides and polysaccharide-enzyme systems, the acid polysaccharide of the submaxillary gland of the pig was isolated and purified. This material is shown to react with large molecular weight proteins to give an insoluble precipitate or clot (depending on salt concentration) at pH levels below their isoelectric points. Thus, with globulins or globins insoluble mucin salts are formed at slightly acid pH levels whereas basic protamines give insoluble mucin salts at pH levels of 7.0 and above. This suggests that the insoluble mucin fractions of human saliva may be salts of mucopolysaccharides with basic proteins, possibly of the histone type. The high viscosity of the mucopolysaccharides is further raised by the presence of proteins when the pH of the solution is at or slightly below their isoelectric points, indicating the presence of soluble polysaccharide-protein salts of extremely large molecular configuration. In such cases, high enough viscosities are achieved to produce thixotropic gels.

47. Influence of CO_2 on the solubility of calcium in saliva. *S. Wah Leung, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* In the course of investigating the possible mechanism of oral calculus formation, the influence of salivary CO_2 on the solubility of salivary Ca was studied. Paraffin-stimulated saliva was collected under oil 1 to 2 hours after breakfast and divided into 4 portions. One portion was immediately analyzed for Ca and CO_2 content and served as the control. Portions II and III were centrifuged at 3500 r.p.m. for 30 minutes, protected and unprotected by liquid paraffin, respectively, and the supernatant analyzed for the above constituents. Portion IV was bubbled for 10 minutes with CO_2-free compressed air in order to remove as much of the CO_2 as possible and then was centrifuged and analyzed. The results indicate that centrifugation, per se, will cause the loss of small amounts of CO_2 (2-3 per cent) and the precipitation of some Ca (4 per cent). The mechanical removal of larger amounts of CO_2 (28 per cent) will result in the precipitation of a considerable quantity (33 per cent) of Ca normally in solution. The solubility of salivary Ca, therefore, appears to depend in some measure on the CO_2 content.

48. EROSION AND CITRATE CONTENT OF SALIVA. *I. Zipkin and F. J. McClure, Dental Research Section, Division of Physiology, Experimental Biology, and Medicine Institute, National Institute of Health, Bethesda, Md.* Citric acid was determined in the stimulated saliva of 61 individuals without erosion, and in 60 individuals with erosion. The subjects varied from 27 to 68 years in age. The Perlman, Lardy, and Johnson modification was adapted to the analysis of citric acid in ten Ml. of saliva. Analysis of the data by the method of multiple correlation has shown that the salivary citric acid content is significantly related to both the age of the individual and the degree of erosion. In a random selection of 83 individuals, grouped according to age, 21 per cent of the 27 to 39 age group, 32 per cent of the 40 to 49 age group, and 32 per cent of the group over 50 years of age showed some evidence of erosion. Preliminary analyses of human dentin and enamel for citric acid have indicated that dentin contains approximately one per cent citric acid and enamel contains approximately one-tenth per cent citric acid. Although teeth in the same mouth show a similar citric acid content, the amount varies considerably from one individual to another. Work is in progress to determine the citric acid content of dentin and enamel of sound and carious human teeth.

49. THE EFFECT OF VITAMIN D ON CARIES IN THE SYRIAN HAMSTER. *Hyman J. V. Goldberg, Paul H. Keyes, J. Edward Gilda, and Kanwar L. Shourie, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Seventy-two animals, at the age of 30 days, were distributed according to sex and litter mates into five groups (8 males and 8 females in four groups and 8 females in the fifth) and were fed the following: Groups I and II, coarse rachitogenic diet; Groups III and IV, fine rachitogenic diet; Group V, control, stock chow. No diets were supplemented for a basal period of 50 days, then vitamin D was administered bi-weekly to Groups I and III for 45 days. At necropsy, line tests (radius and ulna) revealed no evidence of vitamin D deficiency. Groups I, II, and V (coarse diet) exhibited no caries. Average total scores: Group III female, 52; male, 97; Group IV, female, 46; male, 88—no significant differences.

50. THE METHOD FOR MEASURING THE AMINO ACID IN SALIVA AND SALIVARY PROTEINS. *P. Terrill and L. S. Fosdick, Chemistry Department, Northwestern University Dental School, Chicago, Ill.* In 1943 Consdon of England devised the method of separating amino acids by means of partition chromatography using columns of silica gel. He mentioned that separations could be made simply by the use of filter paper strips and by using phenol-water or, in some cases, butyl alcohol-water mixtures as the partition fluid. This method was tested in relation to the separation of amino acids in saliva and salivary hydrolysates, and it was found that amino acids in a concentration of from two to fifty gamma could be detected. Furthermore, by developing a color on the paper strips by means of ninhydrine, a quantitative separation and identification could be effected. The amino acid concentration in freshly secreted saliva is extremely low, and in most cases beyond the sensitivity of this method, but the amino acid concentration in salivary hydrolysates and putrefied saliva can readily be detected.

51. THE AMINO ACID CONTENT OF NORMAL AND HYDROLYZED SALIVA AND SALIVARY PROTEIN. *H. Barnes and L. S. Fosdick, Chemistry Department, Northwestern University Dental School, Chicago, Ill.* It has long been known that saliva from caries-immune individuals will not support the growth of *Lactobacillus acidophilus,* while the saliva from caries-active individuals will support the growth of the organism. The causes of this difference are not known, but there are indications that the difference may be the ammonia content, the presence or

absence of sufficient carbohydrate substrate, the presence or absence of immune bodies, the presence or absence of necessary vitamins, or the presence or absence of certain amino acids essential for the growth of the organism. Little work has been done on any of these factors with the exception of the ammonia content of the saliva. This paper deals with the amino acid content. The amino acids may be secreted as such in the saliva, or they may be present as peptides in the salivary proteins. If present as peptides in the salivary proteins, it is quite probable that they must be liberated by proteolysis or putrefaction before they would have any effect on the bacterial flora. For this reason the free amino acid content, the total amino acid content after acid hydrolysis and the amino acid content of the saliva after varying degrees of putrefaction was determined. The method of analysis was by the use of paper chromatography. In most instances phenol and water were used as the partition fluids. It was found that the free amino acid concentration in saliva was exceedingly small and that before any appreciable quantities could be determined the salivary proteins must first be hydrolyzed.

52. THE DETERMINATION OF OXYGEN CONSUMPTION OF HUMAN GINGIVA BY THE WARBURG MANOMETRIC TECHNIC. *Irving Glickman, Samuel Turesky, and Rachel Hill, Tufts College Dental School, Boston, Mass.* A series of experiments was conducted to determine (1) the applicability of the Warburg manometric Technic for the determination of oxygen consumption in human gingiva and (2) whether the clinical and microscopic changes in various phases of gingival inflammation were accompanied by correlated alterations in oxygen consumption. The findings indicate that the oxygen consumption of human gingiva is measureable by this technic. In 52 specimens from 27 patients in whom the microscopic gingival changes varies from normal to marked chronic inflammation and hyperplasia, the QO_2 varied from .5 to 3.5. An average QO_2 value of 2.5 was obtained in 14 specimens from seven patients with clinically diagnosed chronic marginal gingivitis.

53. ALKALINE PHOSPHATASE IN PULPAL TISSUE OF HUMAN TEETH. *Robert J. Bruckner, D.D.S., School of Dentistry, Western Reserve University, Cleveland, Ohio.* Because ordinary methods of decalcification destroy the activity of alkaline phosphatase, histological demonstration of the presence of this enzyme in tissues concerned with calcification has been restricted. Such a handicap is especially operative in the study of dental tissues so that most investigation has been carried out on material derived from mammalian sources other than human. The present study concerns the demonstration of alkaline phosphatase in sections of undecalcified and decalcified dental tissues of a human term fetus in which dentin formation and calcification are in progress. The presence of the enzyme in human pulpal tissue is confirmed and the extent to which decalcification may be carried out (by employing the method of Lorch) with subsequent successful demonstration of the enzyme is indicated.

54. pH AND THE ION-BASE RELATIONSHIP IN SOLUTIONS OF LOCAL ANESTHETICS. *G. W. Rapp, Ph.D., Loyola University School of Dentistry, Chicago, Ill.* Titration curves of anesthetic solutions were used to calculate the ion-base relationship of anesthetic molecules at several pH values. These ratios were compared with the rates of diffusion of various local anesthetic molecules through living barriers. These two phenomena—the ion-base relationships and the diffusion rates—were studied in the light of clinical production of nerve block anesthesia.

55. A MODIFICATION OF AN APPLICATOR USED IN DENTAL ANESTHESIA INDUCED BY LOCAL REFRIGERATION. *S. Robert Howell, D.M.D., Carl A. Schlack, D.D.S.,*

and B. L. Taylor, U. S. Naval Dental School, Bethesda, Md. A modification of a gingival applicator to cool the root areas of teeth for the purpose of inducing anesthesia is described. It consists of two copper boxes arranged one on the buccal side and one on the lingual side of the tooth to be anesthetized, connected by rubber tubing, and held in position by a spring clamp fixed to the sides of the boxes. The whole unit is encased in a flexible vinyl resin covering; the resin on the inner surfaces of the applicator is heavily impregnated with amalgam filings for better conductivity. The box on the buccal side is divided into an upper and lower compartment so that the refrigerant passes from the refrigerating unit to the upper compartment of the buccal box, travels via rubber tubing to the lingual box and then back to the lower compartment of the buccal box and out to the unit. A right and left anterior applicator and a right and left posterior applicator comprise the four types employing this principle. The compact unit is easily sterilized by boiling and ordinary chemical means. It is readily interchangeable and may be adapted to all regions of the mouth. It permits increased vision and working area for the operator. Refinement of both the unit and the applicator for commercial manufacture would render refrigeration anesthesia a practical aid in the dental office.

56. CHANGES IN THE TEMPOROMANDIBULAR CONDYLE OF THE RAT RESULTING FROM NUTRITIONAL DISTURBANCES, INCLUDING DEFICIENCIES IN PROTEIN, PHOSPHORUS, VITAMIN A, RIBOFLAVIN, BIOTIN, AND PANTOTHENIC ACID. *D. A. Collins, H. Becks, M. Nelson, and H. M. Evans, College of Dentistry, University of California, San Francisco, Calif.* Changes in the mandibular condyle as the result of various nutritional deficiencies were studied in the rat (Long-Evans strain). Included in this report are animals deficient in protein, phosphorus, vitamin A, riboflavin, biotin, and pantothenic acid. Protein deficiency produced dwarfing of the condyle and lack of maturation of cartilage as evidenced by the maintenance of juvenile characteristics. An extreme phosphorus deficiency inhibited maturation of cartilage and resulted in the formation of marked osteoid tissue in neck and ramus, producing an extreme form of rickets. In a vitamin A deficiency new cartilage formation was inhibited and produced a degeneration of the cartilage. Normal marrow tissue was replaced by fibrous tissues. Riboflavin deficiency showed no effect on the mandibular condyle. Biotin deficiency produced little change in the chondrogenetic process, but greatly reduced appositional growth around trabeculae accompanied by a replacement of normal marrow by fibrous tissue. The pantothenic acid deficiency resulted in necrosis and resorption of the mandibular condyle and fibrous replacement similar to an osteodystrophy. Neoplastic periosteal bone growth was also observed.

VIII. FIFTH SESSION: SECTION VA; MORNING; JUNE 20; ABSTRACTS 57-68

57. ON RECORDING SERIAL SECTIONS FOR TEACHING AND RESEARCH (16 MM. MOTION PICTURE). *Erling S. Hegre and Alton D. Brashear, Department of Anatomy, Medical College of Virginia, Richmond, Va.* A 16 mm. film shows a complete series of sectional levels through a 10 mm. pig embryo. The block surface method of staining (*Anat. Rec.* **97**: 21-28, 1947) makes it possible to prepare a photographic record of undistorted serial sections through an embedded specimen. The resulting film is available for continuous projection. It can also be used in making a reconstruction of the embryo for research purposes. Plans have been made to employ this method to study the developmental anatomy of the head in older embryos.

58. METHOD OF FIXING PERIODONTAL TISSUE. *Robert E. Moyers, D.D.S., College of Dentistry, State University of Iowa, Iowa City, Iowa.* In order to study the immediate reaction of the periodontal membrane to orthodontic trauma, a

method of perfusion fixation was devised. This preserves the status of the tissue the instant it was compressed or stretched. Two perfusion procedures were described with color photographs taken during the process shown as well.

59. GLYCOGEN AND CARBOHYDRATE-PROTEIN COMPLEX IN DEVELOPING TEETH OF THE RAT. *Milton B. Engel, D.D.S., M.S., College of Dentistry and College of Medicine, University of Illinois, Chicago, Ill.* Undecalcified paraffin and hard wax sections of rat teeth from animals up to 16 days of age were prepared by freezing and drying. The sections were then treated with the periodic acid fuchsin-sulfite reagents to demonstrate glycogen and carbohydrate-protein complexes. Glycogen was found to occur in the malpighian layer of the oral epithelium, in the dental lamina, and at varying times in the layers of the enamel epithelium with the exception of the ameloblasts. Only in the incisor are these cells shown to contain glycogen. The odontoblasts and pulp cells of the incisor also contain this substance. In a few instances glycogen was found in the odontoblasts and pulpal cells of the molars. Glycoprotein was visible in the cells of the outer enamel epithelium stellate reticulum, stratum intermedium, in the processes of the connective tissue cells, in the cement substance between the cells, and in the basement membrane of the connective tissue. Glycoprotein granules were observed to appear in the cytoplasm of the odontoblasts and the ameloblasts prior to the formation of enamel and dentin. The aggregation of the material in the ameloblasts changed as these cells differentiated. Since enamel and dentin were shown to contain glycoprotein, it was postulated that cytoplasmic glycoprotein may be associated with the production of these respective matrices. Demonstration of the solubility of the enamel carbohydrate-protein complex below pH 5.5 to 5, except when denatured in formalin, is regarded as particularly significant for the understanding of the pathogenesis of dental caries.

60. EFFECTS OF RIBOFLAVIN DEFICIENCY UPON THE PERIODONTAL TISSUES AND TONGUE OF THE ALBINO RAT. *B. R. Sondhi, B.D.S., L.D.S., R.C.S., A. T. Gatz, Ph.D., M.A., B.A., I. Schour, D.D.S., Ph.D., Sc.D., and J. P. Weinmann, M.D., College of Dentistry, University of Illinois, and Medical School Loyola University, Chicago, Ill.* This study is based on the histologic investigation of the supporting tissues of the upper incisors and molars and of the tongues of albino rats placed on a riboflavin-deficient diet (Table I).

TABLE I

	NUMBER OF ANIMALS	DIET
Group A	5	Normal complete synthetic diet.
B	7	Same as A but completely deficient in riboflavin.
C	8	Complete diet high in fat.
D	12	Same as C but completely deficient in riboflavin.

The changes in Group D were: *Upper Incisors.*—Ulceration of the gingiva, proliferation of the epithelial attachment, resorption of the alveolar bone, deep pocket formation, transformation of fatty into hematopoietic bone marrow, and replacement of adipose tissue by connective tissue. *Upper Molars.*—Necrosis of the gingival papillae, inflammatory reaction characterized by a deficiency of polymorphonuclear leucocytes, and slight proliferation of the epithelial attachment. These changes were initiated by impaction of foreign bodies. *Tongue.*—Ulceration of the mucous membrane, glossitis, and degeneration of the serous glands of von Ebner. Animals in Group B showed similar but much milder changes.

61. MORPHOLOGY AND INCIDENCE OF EPITHELIAL REMNANTS IN THE MOLAR REGION OF THE RAT. *F. M. Wentz, D.D.S., J. P. Weinmann, M.D., and I. Schour, D.D.S., Ph.D., Sc.D., College of Dentistry, University of Illinois, Chicago, Ill.* This investigation was based on the histologic study of the supporting tissue of the molars of 105 normal male and female albino and gray Norway rats varying in age from 75 to 1088 days. In approximately 50 per cent of the animals, epithelial remnants were found, the incidence decreasing with age. Three morphologic types were noted: 1. A small resting type, which decreased in number with increasing age. 2. A proliferating type, which comprised the majority of epithelial remnants. 3. A differentiating type which increased in number with increasing age and was correlated to resorption of the interdental alveolar septum. The majority of the epithelial remnants were found in the interdental area above the normal alveolar crest. It may be assumed that the three morphologic types represented successive stages in the life history of the epithelial remnants. The small resting type, upon proliferation, became transformed into the proliferating type. The latter, particularly when stimulated by traumatic factors, may differentiate to the third type. While the great majority of epithelial remnants are derived from Hertwig's epithelial sheath, some might originate from the epithelium of the gingiva or from the epithelial attachment.

62. PHYSIOLOGIC ATROPHY OF THE INTERDENTAL SEPTUM IN RATS. *Merrill J. Shepro, B.S., D.D.S., M.S., Joseph P. Weinmann, M.D., and Isaac Schour, D.D.S., Ph.D., D.Sc., University of Illinois, College of Dentistry, Chicago, Ill.* This investigation is based upon the histologic study of the alveolar bone of the jaws of 111 rats, ranging in age from 21 to 1170 days. It was found that the alveolar interdental septum undergoes physiologic resorption that increases in severity with age. Its occurrence increased from 8 per cent in the 50 to 75 day age group, to 90 per cent in the 970 to 1170 day age group. This resorptive process proceeds from the periodontal membrane surface of the interseptal bone, and eventually leads to complete atrophy of the interdental septum. The prevalence of this process was the same in all the interdental septa of the molar regions of both upper and lower jaws. This physiologic septal atrophy could not be correlated with the degree of inflammation of the interdnetal papillae, the position of the epithelial attachment, pulpal necrosis, or root resorption. The fact that this process occurred only in the interdental, and not in the interradicular septa, suggests that the etiologic factors are local rather than systemic. It is concluded that the above atrophy of the interdental alveolar septum is a physiologic process induced by interproximal wear of the molar crowns and by physiologic movement and rotation of the teeth.

63. BILATERAL CONDYLAR GROWTH ARREST ASSOCIATED WITH JUVENILE RHEUMATOID ARTHRITIS. *Allan G. Brodie, D.D.S., Ph.D., Milton B. Engel, D.D.S., M.S., and Julius Richmond, M.D., M.S., Colleges of Dentistry and Medicine, University of Illinois, Chicago, Ill.* Endochondral ossification initiated in the condyle contributes a most important impetus to mandibular growth. Growth activity in this area persists from approximately four months in utero to adulthood. Injury to this site therefore, results in dysplastic mandibular growth. Such an injury leading to a bilateral arrest of condylar growth is shown to occur in juvenile rheumatoid arthritis. A series of six consecutive cases of juvenile rheumatoid arthritis were examined by members of the departments of Pediatrics and of Orthodontia to confirm the diagnosis and to ascertain condylar involvement. Lateral and frontal cephalometric roentgenograms and temporomandibular joint laminagraphs supplemented the clinical examination. The findings were consistent and striking. All cases had the typical "vogel gesicht" and the degree of deformity was related to the duration of the disease. Bilateral notching of the lower mandibular border at the antegonion was observed. A Class II, Div. I

occlusal relationship obtained in these cases. All functional movements of the mandible were possible but the range was sometimes limited. The lateral roentgenograms revealed underdeveloped mandibles. The relationship of the mandible to the cranium was markedly disturbed as evidenced by the steep mandibular plane angle, the acute S.N. Gn angle and the more obtuse N.S. Gn angle, all indicative of the failure of downward and forward growth of the mandible. The pharyngeal airway was constricted by encroachment of the tongue and soft structure of the restricted oral area. Laminagraphs of the temporomandibular joint were characterized by blunting and erosion of the condyle and destruction of the temporal surface of the joint. There was evidence of periarticular fibrosis. While this clinical picture cannot be considered pathognomonic of juvenile arthritis, it justifies a strong suspicion of such a diagnosis until otherwise demonstrated.

64. PULP HEALING. *R. L. Glass and H. A. Zander, Tufts College Dental School, Boston, Mass.* Stages of pulp healing are studied by exposing sound, young teeth and capping them with $Ca(OH)_2$ and ZOeugenol. The teeth are extracted at intervals varying from 24 hours to 2½ months and histological sections prepared. Within 24 hours pulps capped with $Ca(OH)_2$ show a superficial zone of necrosis demarcated by a calcific line from healthy pulp tissue. By two weeks, an area of primitive dentin has been formed against this calcific line. After four weeks, undifferentiated cells form odontoblasts, and new dentin is deposited against the primitive dentin to complete healing. In contrast is the hemorrhage and inflammation seen under exposures capped with zinc oxide and eugenol under which no healing occurred.

65. PENICILLIN-DENTIFRICE AND DENTAL CARIES EXPERIENCE IN CHILDREN. *Thomas J. Hill, D.D.S., and Albert H. Kniesner, B.S., D.D.S., School of Dentistry and Institute of Pathology, Western Reserve University, Cleveland, Ohio.* A study was made to determine what benefits, if any, might be obtained from the use of a penicillin-dentifrice by institutionalized children for one year under conditions comparable to the ordinary nonregimented habits of oral hygiene. Mouths of 240 boys, age 8 to 15 years inclusive, were examined with mouth mirrors and exploring tines for existent caries, dental restorations, and missing teeth. Posterior interproximal radiographs were made. Initial susceptibility to dental caries was determined by averaging two oral lactobacilli counts. All salivary samples were collected before brushing the teeth in the morning and before breakfast. Individual bottles of tooth powder were supplied to occupants of 8 cottages. All boys living in 5 cottages were given tooth powder to which had been added 1,000 units of penicillin per gram. The boys of three other cottages used the same type of tooth powder without the penicillin. After one year, the clinical, radiographic, and bacteriological examinations were repeated. Of 108 boys who had used penicillin incorporated in their tooth powder, an average of 2.96 new carious surfaces had developed. Of the 68 boys remaining in the control group, an average of 2.90 new surfaces of caries were found. The lactobacilli counts were generally lowered during the period of this study. Eliminating all those with constantly negative counts, 42 per cent more of the experimental group entered the 100 to 500 lactobacilli per ml. of saliva classification, while 28 per cent more of the control group did the same.

66. A STUDY OF THE COMPARATIVE EFFECTIVENESS OF VARIOUS METHODS OF APPLYING HEAT AND CHEMICAL AGENTS FOR DISINFECTION OF DENTAL INSTRUMENTS. *Holmes T. Knighton, D.D.S., Washington University School of Dentistry, Saint Louis, Mo.* Preliminary tests indicate that: 1. Chemicals accepted by the A.D.A. Council on Dental Therapeutics for disinfection of instruments are effective in killing bacteria as *Staphylococcus aureus, Escherichia coli,* and oral

strains of streptococci on smooth instruments within 5 to 10 minutes, even in presence of saliva. 2. Ten minutes' exposure to boiling water and 15 minutes' exposure in a vapor sterilizer (15 pounds' pressure and 250° F. temperature) afford a wider margin of safety in destroying suspensions of vegetative bacterial cells on rough instruments, than does 10 to 15 minutes' exposure to chemicals that are relatively nonirritating to body tissues. 3. Ten to fifteen minutes' exposure to boiling water, while less effective than autoclaving, is more effective in destroying bacterial spores than is one hour exposure in the vapor sterilizer (20 pounds' pressure and 250° F.) or one hour exposure to chemicals commonly used for instrument disinfection. Tests are being continued so as to include hot oil and molten metal sterilizers.

67. TESTS WITH RADIOACTIVE PHOSPHORUS ON THE ACCURACY OF THE BROMOFORM METHOD FOR THE SEPARATION OF ENAMEL AND DENTIN. *Cynthia Binford and Reidar F. Sognnaes, Harvard School of Dental Medicine, Boston, Mass.* The method described by Manly and Hodge (*J. D. Res.* **18**: 133, 1939) for the preparation of samples of enamel and dentin by centrifuging powdered tooth substance with bromoform has been of great value in dental research. In experiments where the radioactivity of enamel was being studied in this laboratory, it was necessary to know whether or not the enamel samples prepared by this method were completely free of dentin. In order to test this, dentin of known radioactivity was prepared from teeth of animals which had been injected with radioactive phosphorus. The samples of dentin used in these experiments were carefully prepared by the bromoform method, which was repeated several times until no evidence of further separation of enamel was detected. At the same time, nonradioactive enamel from teeth which had been extracted from normal monkeys was separated from dentin by the same procedure. Then samples of the radioactive dentin and nonradioactive enamel were thoroughly mixed dry and then in bromoform. This mixture was then centrifuged in the usual manner to separate the enamel from the dentin. The radioactivity of the original radioactive dentin sample, of the enamel, and of the dentin which had been separated from the mixture of nonradioactive enamel and radioactive dentin and of the bromoform used in the separation were determined by the Geiger-Müller counter. In all cases there was no evidence that the nonradioactive enamel which had been mixed with radioactive dentin had attained any radioactivity during the separation process. No decrease in radioactivity of the radioactive dentin was observed. In addition it was noted that the bromoform used in this procedure was not radioactive, indicating that there were no minute particles suspended in it and that it could be used for further separation procedures.

68. STUDIES OF BACTERIAL PLAQUES AND DENTAL CARIES. I. METHOD FOR IN VIVO PRODUCTION OF BACTERIAL PLAQUES SUITABLE FOR MICROSECTIONING. *John Ennever, Hamilton B. G. Robinson, and Paul C. Kitchin, College of Dentistry and Research Foundation, Ohio State University, Columbus, Ohio.* The study of sections through bacterial plaques should give information of value in dental caries studies. Ground and decalcified sections are inadequate for this purpose, but it has been demonstrated that plaques which are morphologically similar occur on tooth substance and celloidin in the mouth. Removable dentures were constructed, each bearing a single celloidin "tooth." These dentures were worn by subjects for various periods of time. After appropriate intervals, the dentures were removed and the celloidin tooth was sectioned through plaque-bearing areas. The method affords a means for microscopic study of plaque material with little or no disturbance in its relationships. Sections of the material produced on celloidin were shown. The method also gives a means of evaluating the effectiveness of anticaries therapy aimed at bacterial plaque destruction.

IX. Fifth Session: Section VB; Morning; June 20; Abstracts 69-81

69. The possible role of glucoascorbic acid as an anti-vitamin c. *William G. Shafer, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Preliminary studies have been carried out to determine whether or not scurvy can be produced by glucoascorbic acid. Rats fed a synthetic diet containing 10 per cent glucoascorbic developed severe diarrhea, alopecia of the dorsum of the neck, and a greatly reduced rate of growth as compared to litter mate controls. After two weeks, the animals were x-rayed and sacrificed. There were no significant differences in RBC counts or ascorbic acid contents of the liver and kidney between the experimental and control animals. Gross and histological examinations were made of the internal organs, femurs, and jaws. No positive evidence of scurvy could be seen although there was a general engorgement of blood vessels in tissues examined. Hamsters receiving 5 per cent glucoascorbic acid in a synthetic diet consistently lost weight, and died within eight days. Histologic examination showed congestion of internal organs and bone marrow.

70. A method for taking dental roentgenographic records of live hamsters. *Kanwar L. Shourie, Frank Driesinger, and John W. Hein, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* A method for taking roentgenograms of the lower teeth and jaws of live hamsters has been evolved with the hope that it will help in recording the progress of dental decay and periodontal disease in animals maintained in various diets and drugs. Since detailed sharpness in a radiograph, which is of greatest importance for the optimum visualization of minute structures, is inversely related to the sum of motion sharpness plus geometric unsharpness plus resolving power of the film, an effort was made to reduce this sum to a minimum. To accomplish this the following technical factors were employed: nembutal anesthesia, focal spot—2 mm., object film distance $< \frac{1}{2}$ inch, target object distance—23.5 inches, Kvp.—30, cone—15 × 3, Ma—200, filter—none, film—Eastman industrial type M. The picture obtained can be magnified up to × 10.5 without loss of clarity due to film granularity.

71. The effects of 6-propyl thiouracil hypothyroidism on the periodontium of the hamster. *David F. Mitchell, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Forty animals, 49 days of age, were equally distributed into two groups according to litter mates and sex. Probacil (Lederle) was administered in the water of the experimental group at .05 per cent and later increased to .075 and .1 per cent. The diet was stock chow plus weekly supplements. Twenty animals were sacrificed after 6 months, and twenty more after 13 months. In addition, second and third generation animals were raised under the continuous influence of .1 per cent Probacil. Gross and histologic studies were made of femurs, jaws, and thyroid glands of all animals. Findings included a weight and growth lag and thyroid hyperplasia of the experimental group. There was no apparent difference in the incidence or type of gross periodontal disease in the two groups.

72. A dietary aspect of oral calculus. *B. F. Turney, M.S., Loyola University School of Dentistry, Chicago, Ill.* The dietary factor of calcium, phosphate and vitamin D intake as well as the systemic factor of gastric stimulation was studied in relation to salivary secretion and excretion. The object was to ascertain the existence or nonexistence of a mineral "tide" after ingestion of mineral-rich foodstuffs, and its bearing on the rate of oral calculus deposition. Evidence was also gathered which demonstrates a remarkable effect that gastric stimulation has on the salivary output of several normal salivary constituents.

73. Effect of riboflavin deficiency on the mandibular condyle of mice. *Barnet M. Levy, Washington University School of Dentistry, Saint Louis, Mo.* Forty-six weanling mice of strain C57 black were fed a synthetic diet deficient in riboflavin. Animals were sacrificed at intervals of one, two, four, and ten weeks. Some mice were refed the stock ration after four weeks of deficient diet. The mandibular condyle of each animal sacrificed was serially sectioned. The growth cartilage of the condyle shows a progressive decrease in width during the experimental periods, from only a slight narrowing after one week to a marked narrowing by the fourth week, and extreme thinness by the 10th week. The cartilage cells become gradually smaller, and the osteoblasts become small and spindle-shaped. Upon refeeding there is a rapid return of the growing cartilage to normal conditions.

74. Oral manifestations in rats fed synthetic diets deficient in pantothenic acid and biotin. *Daniel E. Ziskin, D.D.S., Maxwell Karshan, Ph.D., George Stein, M.D., D.D.S., and David A. Dragiff, D.D.S., Columbia University, School of Dental and Oral Surgery of the Faculty of Medicine, New York, N. Y.* This was a study of the changes in the oral tissues of rats fed a series of synthetic diets complete in every respect, except pantothenic acid, Panthenol (a synthetic pantothenic acid), biotin, and folic acid which were the experimental variables. In diet No. 1, the four vitamins were omitted for some animals, added singly for others, and given in combinations in a third group. In diet No. 2, egg white replaced the casein. Similar variations of pantothenic acid, Panthenol, biotin, and folic acid were used. Two hundred twelve weanling rats, divided equally as to sex, comprised the experimental material. By the end of the twelfth experimental week, the rats either died or were sacrificed. The skin manifestations, blood chemistry, blood counts, and weights were noted. Those animals receiving diet No. 1 unsupplemented by the experimental variables were chiefly on a pantothenic acid deficient diet, while diet No. 2, unsupplemented, emphasized a lack of biotin. Unprotected groups subsisting on diet No. 1 showed ulcers of the tongue in various sizes characterized by the granular type of necrosis described in previous reports. Unprotected groups subsisting on diet No. 2 showed, grossly, clear and hemorrhagic vesicles on the tongue, of subepithelial or subdermal origin.

75. Changes in the skull and the dentition of the screw-tail mouse. *S. N. Bhaskar, B.D.S., D.D.S., E. C. MacDowell, Sc.D., I. Schour, D.D.S., Ph.D., Sc.D., and J. P. Weinmann, M.D., College of Dentistry, University of Illinois, Chicago, Ill., and Carnegie Institution of Washington, Department of Genetics, Cold Spring Harbor, N. Y.* Screwtail is a mutation outwardly manifest at birth by a coiled tail. Published data indicate that it depends on a recessive gene without sex linkage that originated in a mouse of the CSH-Bagg albino strain. Thirty-three screw-tail and 25 normal mice varying in size from 14½ days in utero to 420 days were variously studied by gross anatomic radiographic and histologic methods. The skull, as well as the whole body, was undersize. The cranial vault was convex instead of flat, and the bones of the vault consisted of a single plate of bone instead of the normal two. The lower jaw in later life becomes grossly undershot and the incisors are usually in malocclusion. The basal ends of the incisors failed to reach their normal positions but remained entirely within the premaxillary bone or not beyond the molars. The incisors showed abnormal attrition, overeruption and later, a folding of their basal ends. The crowns of the molars were smaller and their roots stunted and malformed. The distal malposition of the lower teeth caused some of the molars to lose contact with their antagonists and to overerupt. The occluding molars were in undereruption. The third molars were

often impacted. The eruption of all teeth was delayed. The growth of sutures of the skull was retarded. The normal interdigitation of bone trabeculae of the premaxillary-maxillary suture and the maxillary-palatine suture was missing. The growth at the mandibular condyle was retarded, and the vertical height and length of the mandible were decreased. The gross changes of the skull and the teeth could be explained by a disturbance of the proliferative potencies of the connective tissues of the sutures, the condyles, and the dental papilla. The changes observed did not resemble, in any way, the known effects upon the rodent incisor of endocrine, nutrition, and other experimental interferences.

76. ELECTRON MICROSCOPY OF ENAMEL AND DENTIN. *David B. Scott, D.D.S., M.S., and Ralph W. G. Wyckoff, Ph.D., National Institute of Health, Bethesda, Md.* Further studies have been made of the surface structure of enamel and the internal structure of enamel and dentin by the shadowed collodion replica method which has previously been described (*Pub. Health Rep.* **62**: 1513, 1947). Electron micrographs are presented which demonstrate the granular structure of enamel rods, the apparent sheathlike structure at the periphery, and the interprismatic material. Micrographs of dentin show the structure of the tubules and matrix as revealed by various etching agents, and the character of dentinal fibers which have been isolated by means of different technics.

77. THE EFFECT OF VARIOUS FLUORIDE COMPOUNDS ON CARIES ACTIVITY IN SYRIAN HAMSTERS. *P. H. Keyes and K. Shourie, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.* One hundred two hamsters were divided by litter into six groups. All groups received a cariogenic ration *ad libitum*. Group I received experimental ration and distilled H_2O; Group II, 50 ppm. NaF in diet; Group III, cariogenic ration and approximately 50 ppm. NaF in H_2O; Group IV, experimental ration and NaF subcutaneously; Group V, 50 ppm. CaF_2 in experimental diet; Group VI, 50 ppm. Na_2SiF_6 in experimental ration. Average scores: Group I, ♂ 160.5 and ♀ 126.8; Group II, ♂ 0.8 and ♀ 6.2; Group III, ♂ 0.6 and ♀ 6.9; Group IV results were invalid because of copraphagey and urine contamination of food; Group V, ♂ 185.6 and ♀ 80.0; Group VI, ♂ 39.3 and ♀ 5.7.

78. MORPHOLOGIC CHARACTERISTICS OF CERTAIN CULTURED STRAINS OF ORAL SPIROCHETES AND TREPONEMES PALLIDUM AS REVEALED BY THE ELECTRON MICROSCOPE. *E. G. Hampp, D. B. Scott, and R. W. G. Wyckoff, National Institute of Health, Bethesda, Md.* In this investigation eight cultured strains of the spirochetes were utilized. Two strains of the smaller oral treponemes, four strains of *Borrelia vincenti* and the Nichols and Noguchi strains of *Treponema pallidum*. Collodion covered electron microscopic screens containing the desired organisms were shadowed by oblique evaporation of chromium and studied with an R.C.A. type E.M.U. microscope. The external surfaces of the three species of organisms studied exhibited striking similarity in structure. An envelope of amorphous material was found surrounding most of the spirochetes. In addition, cordlike structures were demonstrated which were closely adherent and wound about the individual cells. Terminal filaments and flagellalike appendages were demonstrated. Spirochetal granules were found closely adherent to the organisms and also separated from the spirochetes.

79. PREMATURE DECIDUOUS CANINE ROOT RESORPTION ACCOMPANYING PERMANENT SECOND INCISOR ERUPTION. *Kenneth E. Wessels, D.D.S., and Virgil D. Cheyne, D.D.S., Ph.D., State University of Iowa, Iowa City, Iowa.* Data are presented on premature root resorption, eruption, and exfoliation in the deciduous canine and permanent second incisor area of 565 individuals, according to

sex, age, tooth position, single and multiple occurrence of the condition. Examination of complete roentgenographic surveys of the patients revealed 69 (12 per cent) with premature root resorption of 147 deciduous canine, associated with the stimulus of erupting permanent second incisors. A total of 49 individuals (71 per cent) showed multiple involvement. No sex differences were noted. Age range of individuals studied was 59 to 167 months; median age, 90 months. The median range of the resorption process from initiation to complete loss of tooth or lateral incisor eruption was 15 months. No significant difference between values for right and left sides, or maxillary and mandibular values were noted statistically when position of involved tooth was considered. Of the individuals having two canine affected, 64 per cent occurred bilaterally in the upper arch; 25 per cent bilaterally in the lower arch. This difference approaches, but does not reach, the 5 per cent significance level. Of the remaining 11 per cent, upper and lower combinations occurred unilaterally. In no instance was there a maxillary-mandibular combination involving opposite sides of the mouth. The fate of all cases studied was either (1) loss of the deciduous canine before the lateral erupted, or (2) the canine remained and space was provided for the second incisor, with canine loss at a later date. A total of 123 canines were studied through the entire process. Thirty-four per cent exhibited the first outcome and the remainder, the second. Median age of cases associated with the former was 96 months, the latter, 120 months. The results of this study indicate that premature deciduous canine root resorption occurs in a larger percentage of children than has been suspected. In many instances the condition apparently is overcome by natural growth processes.

80. GEOMETRICAL PROGRESSION IN THE TOXICITY OF PROCAINE HYDROCHLORIDE SOLUTIONS. *Frank G. Everett, M.D., D.M.D., and James H. Maloney, University of Oregon Medical School and Dental School, Portland, Ore.* Our previous studies have demonstrated significantly greater depth of pulpal anesthesia with submucous administration of 4 per cent procaine hydrochloride than with 2 per cent solution. Simultaneously a comparative toxicity study of 2 and 4 per cent procaine hydrochloride was undertaken, using mice and rabbits. Identical drug amounts in the 2 concentrations were administered intravenously during 18 to 25 seconds in rabbits, and subcutaneously in mice. The results indicate no significant difference in toxicity for solutions of either strength when the absolute drug amount is kept the same. The findings tend to disprove the theory of the geometrical progression in the toxicity of procaine hydrochloride.

81. AN EXPERIMENTAL AND CLINICAL EVALUATION OF THE COMPARATIVE EFFECTIVENESS OF TWO AND FOUR PER CENT PROCAINE SOLUTIONS FOR LOCAL ANESTHESIA IN DENTISTRY. *Frank G. Everett, M.D., D.M.D., University of Oregon Medical School and Dental School, Portland, Ore.* For certain dental procedures 4 per cent procaine solutions have clinical advantages over the recommended 2 per cent solution; this is particularly true in maxillary submucous infiltration anesthesia for cavity preparation. To measure these advantages we have compared pulpal anesthetic depth in 2 homologous teeth of the upper arch of dogs lightly anesthetized with sodium pentobarbital. Shallow occlusal cavities were prepared in each tooth to such a depth that equal minimal responses were noted when their sensitivity was tested by a weak faradic current. Simultaneous stimulation of each cavity revealed that after the first ten minutes following nerve block with 4 per cent procaine, responses were consistently absent or reduced to a stimulus which would produce a definite pain response in the contralateral tooth blocked with 2 per cent procaine. Clinical tests have corroborated these findings which give objective confirmation to clinical experience.

X. Materials Group: Abstracts of Papers Presented in Sections IIB and IIIB; June 19; Abstracts 82-104

82. Report on American Dental Association specifications no. 5 and no. 7, as viewed by the research representatives of gold manufacturers. *John S. Shell.* During the past year, at the suggestion of Dr. G. C. Paffenbarger, representatives from the research departments of a considerable number of gold manufacturing concerns have met to discuss the American Dental Association specifications number 5 and 7 for cast gold and wrought wire. No unanimity of opinion was possible but a few generalizations regarding the specifications seem to be agreeable to the majority. This discussion is an attempt to present a fair evaluation of the opinions so far obtained and included suggestions which this group feels would be of value to the dental profession.

83. Testing dental elastic impression materials. *James Cressen.* Five popular brands of agar and alginate impression materials were rated by testing them according to their specifications. A new series of original tests were then run on each material and a new rating made. The two methods of testing produced a difference in ratings and it has been shown how the specification tests may lead to misinterpretation, principally in regard to permanent deformation. Based upon findings of this work, several changes are suggested in the existing specifications.

84. Physics and technics of metal inlay laboratory procedures. *Edwin S. Smyd.* Large inlays and bridge abutment castings are best made by indirect methods of inlay fabrication employing metal dies. A study was made of the more significant factors which control casting accuracy. Library research and experimental verification were done on the various casting procedures in vogue today. The characteristics and management of indirect wax patterns were studied, and a method of obtaining uniformly accurate casting results for the various types of patterns were evolved. The hygroscopic expansion principle was employed for the investing procedure in the foregoing study. Qualitative research was undertaken to determine the characteristics of hygroscopic activity as it relates to investments.

85. An electronic strain gauge for measuring biting forces. *A. H. Howell and R. S. Manly.* An electronic strain gauge has been developed for measuring the maximum force which can be exerted by biting on a single tooth. The principle depends upon the change in inductance in a flat spiral coil as a conducting spring is deformed and brought nearer to the coil. The inductance is part of a tuned circuit which is coupled to an oscillator. As the inductance is influenced by the bite, the coupled circuit is progressively detuned and the change is measured by a milliameter in the grid circuit of the oscillator. Complete description and wiring diagram will be given. The element is 7 to 10 mm. thick, including the rubber covering. Four separate elements are used to cover the range from 1 to 300 pounds. From repeated tests on four subjects it was found that two readings must be taken in order to obtain a precision of about 10 per cent.

86. Orthodontic wires of gold alloys and stainless steels for arches and springs. *R. C. Angell.* Gold alloy wires, because of lower modulus of elasticity as compared with stainless steel, serve as better springs if of the same cross section. Modulus of resilience is a measure of this advantage. Smaller cross sections of steel wires are required to give same load deflection as wires of gold alloy, resulting in higher requirements for elastic limit to do the same work.

Characteristics as measured in tension may lead to wrong conclusions as compared to characteristics measured in bending. Soldering to stainless steel wires reduce their ability to serve as springs, making them markedly inferior to gold alloy wires which can be heat-treated after soldering.

87. A STUDY OF HYGROSCOPIC EXPANSION IN DENTAL INVESTMENT. *E. W. Skinner and Francisco Degni.* Several methods for the measurement of hygroscopic expansion were studied. The most reliable method was to confine the investment in an asbestos-lined casting ring, and to measure the expansion at the open end with a dial gauge. According to the data obtained, the greater the amount of hydrocal and the less the quartz content of the investment, the less is the hygroscopic expansion. The amount of water present externally to the investment during setting affects the amount of the hygroscopic expansion. The lower the temperature of the water bath, the lower the expansion. Possible theories to account for the hygroscopic expansion will be discussed.

88. VINYL AND MODIFIED VINYL RESINS AS DENTURE BASE MATERIALS, AND A METHOD OF PROCESSING SAME. *Arthur Brown and Robert Muller.* This summary of vinyl materials covers the different types of vinyl resins and shows how these materials in the past ten years have found many useful and unique applications. It is shown that from this class of material has come a product, which when modified to mould and cure at low temperatures and pressures, has a combination of useful properties not available in any other denture materials produced to date. The tests are supported by laboratory findings and backed up by extensive clinical experience. The pressure cast process is described briefly for processing this class of denture material. This method of moulding eliminates moulding variables with the exception of mixing of plaster or investment.

89. SOME OBSERVATIONS ON MAKING A DIMENSIONALLY ACCURATE DENTURE. *Mrs. Naomi S. Steck.* To make a precisely fitting denture of methyl methacrylate denture base material, an expanded cast (0.40 per cent average) upon which the denture was processed, was used to compensate for the curing shrinkage (0.37 per cent average) of the resin. An alginate film was used as a separator. The denture when deflasked deviated from the original measurements only + 0.02 per cent average. After being immersed in water at 37° C. for 30 days, a linear dimensional change of – 0.02 per cent was observed.

90. WHY DENTURES WARP ON REPAIRING. *H. J. Caul, I. C. Schoonover, and George Dickson.* A consideration of factors which may cause the warpage of dentures is presented. The presence of residual strain, its formation, reduction, or elimination; the changing water content of the resin, and the effect of the flasking gypsum, and the technique of using it is discussed.

91. ABRASION RESISTANCE OF ACRYLIC RESIN TEETH. *Norman H. C. Griffiths.* The abrasion resistance of four types of acrylic resin teeth was determined by loss of weight after brushing for fifty thousand strokes with a toothbrush in a slurry of calcium carbonate. The teeth employed were two commercial brands of injection molded acrylic resin teeth, one commercial brand of vinyl-acrylic teeth, and teeth molded in the laboratory from methyl methacrylate. The vinyl-acrylic teeth exhibited the least amount of abrasion, the two brands of injection molded teeth were next in abrasion resistance, and the laboratory molded teeth abraded the most. The abrasion loss appeared to be in inverse ratio to the Knoop hardness numbers of the teeth. Porcelain teeth exhibited no appreciable loss of weight under this treatment. Abrasion tests made on the teeth with Knoop indentations, according to the method of Souder, showed similar results to the

loss in weight method. However, the tooth dentin appeared to abrade more than any of the acrylic teeth when it was subjected to the last mentioned test under the same conditions of treatment.

92. A COMPARISON OF COMPRESSION AND INJECTION MOLDING OF ACRYLIC DENTURE RESINS. *A. H. Grunewald, George C. Paffenbarger, and I. C. Schoonover.* A discussion is presented on the effect of compression and injection molding on the hardness, density, transverse strength, reproduction of the articulator set up in wax, shrinkage, volume and weight changes, and strain in acrylic resin dentures, and acrylic-vinyl resin copolymers.

93. RELEASE OF STRAIN IN ACRYLIC DENTURES. *E. W. Skinner, Edwin H. Smith, and Harry P. Darley.* Acrylic resin upper dentures have been constructed under identical conditions as nearly as possible, so far as mold space, tooth form, and arrangement, etc. The dentures were processed with methyl methacrylate resin by both the compression and injection molding methods. Measurements were made of the curing shrinkage and the water sorption by weight, volume, and linear change across the posterior portion of the denture. Both the weight and volume changes during water sorption for 60 days at 37° C. were according to expectations, but the linear change in general exhibited a contraction during the first week, which was followed by an expansion. Only in the case of dentures molded by injection was a linear expansion manifested greater than that of the original dimension after processing. It is postulated that these anomalous dimensional changes are caused by strain release.

94. COMPARATIVE HARDNESS OF HUMAN ENAMEL AND SYNTHETIC RESIN. *F. A. Slack, Jr.* The method of testing unrelated materials comparatively, in the past, has resulted in meaningless figures which do not accurately forecast clinical results. According to Brinell figures, porcelain and human enamel are so much harder than synthetic resin, that the use of synthetic resin for tooth restorations would be considered ridiculous. Clinical evidence refutes this test data. By testing many teeth, both human and of synthetic resin, by methods which determine their relative hardness more closely, it has been found that a hardness relationship exists which more accurately parallels clinical observation of these two materials.

95. THE WORK OF THE SPECIFICATION COMMITTEE. *Walter S. Crowell.* The Chairman of the Specifications Committee described its work during the past two years. Plans for cooperation with the Dental Materials Group at the National Bureau of Standards and the A.D.A. Research Fellowship were presented.

96. GOLD, PLATINUM AND PALLADIUM IN SILVER AMALGAM ALLOY. *E. Liebig.* A report is given on the addition of small quantities of gold, platinum, and palladium to silver amalgam alloys and their effect on the properties of the amalgam. A silver amalgam alloy of average composition which would comply with A.D.A. specifications was selected for a control. Gold, palladium, and platinum in various amounts were added to the control alloy and were substituted for like amounts of either silver or copper.

97. A TECHNIC FOR AMALGAMATION OF A ONE PER CENT ZINC ALLOY UNDER WATER WITHOUT AFTER EXPANSION. *Herbert D. Ayers.* As a result of a problem in mixing technic, it became necessary to study the setting changes of amalgam using various methods and concentrations. Setting changes were determined by the interferometer. Twenty-one days was selected as the adequate time for continuing the interferometer readings. In the presence of distilled water and

various saline solutions specimens showed definite after expansion in this length of time. The test specimens were then removed, measured with a micrometer and stored for continued checks which would show any latent expansion after the twenty-one-day period. On this basis approximately fifty curves were plated covering several procedures. The intensity of the mixing procedure was controlled by the use of a definite standard time of mechanical amalgamation followed by a mulling period in the presence of water. The specimens were then prepared in the usual manner and placed under the interferometer plate and readings taken starting ten minutes after the beginning of the mix. Mixes of 1 per cent zinc alloy and mercury were amalgamated in contact with various concentrations of HCl, and other chemicals. Interferometer readings were made for preliminary periods. The changes during the first 24 hours have been eliminated. One-half cubic centimeter of the solution was mixed with the alloy, 5:9 ratio for 12 seconds in a mechanical mixer, the mix was mulled one minute in running tap water, dried by wiping, and packed. Other chemical treatments are covered briefly. A few analyses to locate the zinc are included.

98. CLINICAL SURVEY OF AMALGAM FAILURES. *R. W. Phillips and Harry J. Healy.* A clinical survey of over 1,500 amalgam failures was made. These failures were classified according to fracture, recurrent caries, dimensional change, and periodontal involvement. Each of these large divisions was then broken down into individual factors which contributed to the failure of that restoration, such as cavity preparation, faulty manipulation, improper selection of material, etc. Failures due to cavity preparation have been subdivided into different sections, such as no extension for prevention, insufficient provision for bulk of amalgam, etc.

99. CONTAMINATION OF AMALGAM. *George Dickson and D. L. Smith.* A sound motion picture in color showing the contamination of amalgam with moisture from various sources is shown. Both clinical and laboratory tests are given to show the physical and chemical consequences of the contamination.

100. PULP REACTION TO DENTAL CEMENTS. *H. A. Zander.* Methods for testing the biological properties of dental materials, particularly dental cements, is presented. The advantages and disadvantages of experimental histological studies and studies using radioactive materials as tracers is discussed.

101. A PRELIMINARY REPORT ON THE DETERIORATION OF SOME DENTAL MATERIALS IN THE TROPICS. *T. C. Fischer and I. C. Schoonover.* A review of the experience of the armed services with dental materials in the tropics, together with some confirming laboratory tests on silicate cement and acrylic resin for dentures is given.

102. A PRELIMINARY REPORT ON THE CORRELATION OF LABORATORY AND CLINICAL TESTS ON SILICATE CEMENTS. *G. F. Glasson and G. C. Paffenbarger.* Evidence of definite correlation between the findings in laboratory tests on silicate cements and the behavior of silicate cement restorations placed in the mouth in dentures is demonstrated.

103. REVISION OF THE A.D.A. SPECIFICATIONS FOR SILICATE CEMENT. *A. C. Swaney.* A proposed revision of the current American Dental Association Specification for silicate cement including the refinement of procedure for preparing the specimens for compressive strength test, reducing the time of several tests from seven days to twenty-four hours, inclusion of a test for discoloration, changing the minimum requirements in several instances, and the definition of a precise mixing technic is discussed.

104. AN APPARATUS FOR THE DETERMINATION OF UNRESTRICTED SETTING EXPANSION OF PLASTERS AND INVESTMENTS. *A. R. Docking and H. K. Worner.* In order to study the "free" setting expansion of dental plasters and investments the material is allowed to set while floating on the surface of mercury. A suitable instrument is described and some results indicating the sensitivity of the method are included. The data being obtained may be of value in helping to elucidate the mechanism of setting of plaster and Hydrocal.

XI. PAPERS READ BY TITLE; ABSTRACTS 105-163

105. A STUDY OF EPITHELIAL RESTS OF THE PERIODONTAL MEMBRANE. *R. Gordon Agnew, School of Dentistry, Baylor University, Dallas, Tex.* Histological studies of the periodontium include the common observance of the so-called epithelial rests, which are usually considered to be residual cells of the Hertwig sheath. Examination of these residual cells would seem to suggest several patterns of cell behavior. Frequently the cells do not seem to increase in size or demonstrate any change. They may undergo calcification. They may stimulate the connective tissue to the formation of cementum, which subsequently may be seen enveloping calcified epithelial cells. Such cementum may remain discrete within the periodontal membrane or may become incorporated more or less smoothly into the body of the cementum. In some instances outcroppings of cementum from the root surfaces may incorporate cells, forming spurs or projections along these cementum surfaces. In other instances, the epithelial cells may be observed within the alveolar process at some distance from the tooth. In such areas they may be discretely scattered in the marrow spaces or may be engulfed within the structure of currently forming bone trabeculae. Variant to the above phenomena is the rare instance where widespread proliferation of epithelial cells within the membrane, assuming almost tumorlike proportions, may stimulate the connective tissue, leading to the absorption of bone on the one side and of cementum on the other. Contiguous areas of cementum absorption and outgrowth may be seen. Peripheral hyaline zones outlining the borders of clumps of epithelial cells may be observed. The material within these hyaline peripheral bands may still show the outlines of epithelial cells or it may have the appearance of noncellular calcified substance; or again, it may consist of bonelike material with enclosed bone cells. The peripheral band may in some areas stain as for calcified substances and may enclose rests in various stages, as above outlined. Hyaline-banded zones may be seen in process of incorporation into cementum or bone.

106. OSSIFICATION OF THE THIRD METACARPAL OF THE FEMALE RAT. IV. THE EFFECT OF THE ANTERIOR HYPOPHYSEAL GROWTH HORMONE ON EPIPHYSEAL CLOSURE IN NORMAL RATS. *C. Willet Asling, Hermann Becks, Miriam E. Simpson, Choh Hao Li and Herbert M. Evans, College of Dentistry, University of California, San Francisco, Calif.* The administration of growth hormone to 18 female rats of the Long-Evans strain for 10, 20, and 30 days, starting at 81 days of age, resulted in gains in body weight and length which greatly exceeded those of 18 injected rats of corresponding ages. However, the length of the third metacarpal bone of the injected rats was not significantly greater than that of their controls. The presence of an intact epiphyseal cartilage plate in this bone at the beginning of the experiment (6 rats) was therefore no indication that a capacity for growth still existed. In none of the injected rats could there be demonstrated a re-establishment of the histologic characteristics of the epiphyseal plate typical for active growth. Epiphyseal closure was neither accelerated nor prevented by the administration of growth hormone. No hypothesis can be

advanced at present to explain adequately the paradox that following injection of growth hormone at this age the metacarpal did not participate in the active skeletal growth displayed by these animals.

107. PENICILLIN IN STOMATOLOGY. *V. Bažant, M.D., and F. Votruba, M.D., Faculty of Dentistry, University of Prague, Czechoslovakia.* Penicillin was administered parenterally in cases of various acute inflammatory processes, of acute and chronic inflammation of lymphatic glands and maxillary sinus, in fractures, and major operations in order to prevent the infection. Most processes were either stopped or localized and often the abscess which was expected to form did not form at all.

108. THE GROWTH OF HYPOPHYSECTOMIZED FEMALE RATS FOLLOWING CHRONIC TREATMENT WITH PURE PITUITARY GROWTH HORMONE. I. SKETAL CHANGES: TIBIA, COSTOCHONDRAL JUNCTION, AND CAUDAL VERTEBRA. *Hermann Becks, Herbert M. Evans, C. Willet Asling, M. E. Simpson, and Choh Hao Li, University of California, San Francisco, Calif.* The skeletons of rats chronically treated with pure pituitary growth hormone were examined roentgenographically and histologically, and compared with those of hypophysectomized uninjected controls. Endochondral ossification was studied in the tibia, metacarpal, costochondral junction, and caudal vertebrae. Cessation of osteogenesis and narrowing of the epiphyseal cartilages were already evident in the controls at the beginning of the experimental period (12 days after hypophysectomy). However, the cartilages remained even until autopsy, though often sealed from the marrow cavity by bone. Linear increase was found in all measured bones from injected rats. The proximal tibial epiphyseal cartilage was still active, with an average width of 293 microns, compared with 189 microns in controls, and there was continued osteogenesis as well as chondrogenesis. On the other hand, at the distal end of the tibia and in the metacarpal, epiphyseal closure was either impending or the cartilage plate had disappeared. At the costochondral junction chondrogenesis was proceeding at a slow rate, but with little evidence of osteogenesis. In the caudal vertebral epiphyses, although the cartilage plates were not noticeably widened, there was continuing capillary erosion and osteogenesis. Thus, growth was re-established in all bones studied.

109. ENAMEL FORMATION IN THE AMELOBLASTOMA. *Joseph L. Bernier, D.D.S., M.S., Army Institute of Pathology, Washington, D. C.* Serial sections of forty cases of ameloblastomas have failed to reveal the presence of histologically identifiable enamel matrix. Foci of calcification, when noted appears to represent terminal decalcification in masses of degenerating epithelial cells. The assumption that the ameloblastoma arises from ameloblastic tissue which has not differentiated sufficiently to produce enamel seems warranted. This study is being continued in an attempt to determine whether these findings will obtain in an additional group of approximately fifty ameloblastomas.

110. THE DENTITION AND THE ALVEOLAR BONE OF THE ALBINO MOUSE. *S. N. Bhaskar, B.D.S., D.D.S., J. P. Weinmann, M.D., and I. Schour, D.D.S., Ph.D., Sc.D., College of Dentistry, University of Illinois, Chicago, Ill.* This investigation is based on gross anatomic, roentgenologic and histologic investigation of the dentition and the alveolar bone in a group of 29 CSH-Bagg albino mice varying in age from 14½ days in utero to 80 days. The number and the anatomy of the molars and the incisors was found to be similar to that of the rat, with the exception that the accessory cusps in the upper first and the second molars are more completely developed in the mouse. The anatomical and developmental characteristics are summarized below (Table I).

TABLE I

THE ANATOMY AND THE CHRONOLOGY OF THE DEVELOPMENT OF THE DENTITION OF THE ALBINO MOUSE

	UPPER MOLARS			LOWER MOLARS			
	M_1	M_2	M_3	M_1	M_2	M_3	INCISORS
Anatomy:							
Cusps:							
Main	5	4	3 or 4	7	5	3	-
Accessory	3	2	-	-	-	-	-
Roots	3	3	2	2	2	1	-
Development:			In Days				
Dentin formation begins	0	2	9	0	2	9	17 days in utero
Enamel formation begins	1	3	10	1	3	10	18 days in utero
Crown completed	6	8	17	6	8	17	-
Bifurcation of roots starts	6	8	17	6	8	17	-
Eruption	15	15-20	28	15	15-20	28	10

The upper incisor begins to develop in the premaxilla and grows posteriorly at its basal end so that after the fourth day of life, the tooth lies partly in the premaxilla and partly in the maxillary bone. The anatomic relation between the incisor and the premaxillary and the maxillary bones changes continuously until it becomes more or less constant at about 20 days. In its backward growth, the basal end of the incisor travels in an arc of a circle, so that its epithelial diaphragm and the fundic bone which lies inclined backward and upward at birth become horizontal at 20 days of life. The alveolar bone of the upper incisor which at birth is formed entirely by the premaxilla is, at 4 days of age formed partly by the maxillary and partly by the premaxillary bone. At 20 days the concave side of the alveolus is entirely formed by the premaxilla; the fundic bone and the bone on the basal one-third of the convex side is formed by the maxilla, and the rest of the alveolar bone on the convex side is by the premaxillary bone. The basal end of the mandibular incisor is, at birth, situated below the first molar tooth germ. It continues to grow backward until it is placed below the third molar tooth germ at 6 days and posterior to it at 10 days of life.

111. BACTERIEMIA AFTER TOOTH EXTRACTION. *V. I. Borovanský, M.D., Governmental Hospital, Prague, Czechoslovakia.* In 50 cases of pulpless tooth extractions, the arterial and venal blood were examined immediately and at regular intervals after the tooth extraction. In 30 per cent of the cases there was a bacteriemia as early as 15 minutes after the extraction. In all the cases, streptococci could have been cultivated.

112. SEPSIS OF DENTAL ORIGIN BY STREPTOCOCCUS α. *V. I. Borovanský, M.D., Governmental Hospital, Prague, Czechoslovakia.* Five cases of streptococcus α sepsis followed the inflammatory process in the teeth. One case had an acute course, the others a slow one, having at first vague symptoms (lassitude), later on temperature up to 39° C. In the four chronic cases sepsis developed into polyarthritis; spleen and liver were enlarged in three cases; anemia and decrease of arterial pressure was always observed. In three cases metastatic damage of the body developed (pericarditis, pleuritis, pneumonia). In dental foci streptococcus α was found; in two cases, a bacteriemia with streptococcus immediately after the tooth extraction. Two of the patients died. The autopsy showed no changes of the heart. Three patients were healed by help of blood transfusion and antiseptic treatment.

113. SKIN TEST IN DENTAL FOCAL INFECTION. *V. J. Borovanský, M.D., Governmental Hospital, Prague, Czechoslovakia.* It was proved that all cases of actual dental focal infection have a positive skin test with the streptococci α and γ from the dental foci. From the result of the desensitization and immunization, used therapeutically, it became evident that allergy plays a part in focal infection and that the streptococci α and γ are responsible for dental focal infection in most cases.

114. THE VASOCONSTRICTOR CONTENT OF LOCAL ANESTHETICS AND THE INCIDENCE OF DRY SOCKETS. *M. E. Chapin, D.D.S., and G. W. Rapp, Ph.D., Loyola University School of Dentistry, Chicago, Ill.* The influence of epinephrine and Cobefrin on the incidence of postextraction infections commonly referred to as dry sockets was investigated. A study was made of the incidence of such dry sockets in patients after extractions done under procaine hydrochloride, Monocaine hydrochloride, and Intracaine hydrochloride anesthesia, and in the presence or absence of variable quantities of vasoconstrictors. The object was to test the hypothesis that the ischemia from vasoconstrictors is a major factor in the etiology of these conditions.

115. THE GROWTH OF HYPOPHYSECTOMIZED FEMALE RATS FOLLOWING CHRONIC TREATMENT WITH PURE PITUITARY GROWTH HORMONE. II. SKELETAL CHANGES: SKULL AND DENTITION. *D. A. Collins, H. Becks, M. E. Simpson, and H. M. Evans, University of California, San Francisco, Calif.* The growth and transformation of the mandibular condyle was studied roentgenographically and histologically in hypophysectomized rats (operation 28 days of age) which received daily injections of growth hormone for 437 days beginning 12 days after the operation. Several changes were observed in the mandibular condyle of the hypophysectomized rats which received chronic injections of growth hormone. These were almost identical for all animals studied. The condyles were decidedly larger than the normal controls of the same age. There was a noticeable increase in the horizontal dimension; the vertical measurements were approximately one-third greater than those of the normal controls. Histologically the bone as well as the marrow tissue and cartilage of the injected rats were similar to those described previously for the growing adult rat. Erosion was greatly reduced, vesiculation of the chondrocytes had ceased, and the intermediate zone and zone of large cells were calcifying. A severe distortion was seen in every condyle as compared with the normal and the hypophysectomized controls. In the neck and shaft of the ramus, the bone trabeculae had fused, leaving only a few marrow spaces. The histologic findings revealed that chronic injections of growth hormone starting soon after hypophysectomy produces growth in the mandibular condyle equal to and surpassing that in the normal rat.

116. CARIES STUDIES IN DESALIVATED RATS RECEIVING IODOACETIC ACID PARENTERALLY. *Peter P. Dale, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* The possible systemic mechanism of action of Iodoacetate in reducing experimental rat caries (*J. D. Res.* **22**: 257, 1943) was investigated. Forty-two female litter mate albino rats, aged 25 to 30 days, were divided into three groups of 14 animals each. Group I served as controls; II and III were desalivated one week before the experimental run. All were fed unrestricted amounts of the H.W.C. coarse corn meal diet for 150 days. Group III received subcutaneous injections of 1 c.c. of 400 ppm. iodoacetic acid (adjusted to pH 7.2 with NaOH) every second day. Animal weights and water

consumption were recorded. On completion of the experiment, the rats were sacrificed, jaws removed, and the molar teeth were scored for caries under a binocular microscope (×20) using a modification of the method of Cox et al. Average weight curves disclosed a marked reduction in rate of gain in desalivated rats of Groups II and III which may in part be attributed to a lowered water consumption. The daily average water consumption per animal for 150 days was: I—10.7 c.c.; II—9.2 c.c.; and III—9.4 c.c. Desalivation increased the incidence of caries, and parenteral administration of iodoacetic acid was mildly effective (24 per cent reduction) in limiting caries. Average caries scores for the various groups were I—14.0, II—46.8, and III—35.7. Data from previous experiments (*J. D. Res.* **22**: 257, 1943) disclosed that Iodoacetate was more effective systemically when injected into normal animals (84 per cent reduction) and suggested that the caries inhibiting influence was exerted via the saliva.

117. CHANGES IN THE COMPOSITION OF BONE WITH AGE. *Martin L. Deakins, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Chemical analyses of bone expressed in Gm./c.c. of fresh tissue (instead of percentages) show absolute rather than relative changes in ash, organic, and water contents with age. Analyses of human clavicles from birth to 89 years of age revealed that the organic fraction increases with the degree of calcification. Calcification reaches a maximum at about 20 and begins to decline about 60. The method has been applied to human enamel (*J. Biol. Chem.* **156**: 77, 1944).

118. PLANIMETRIC ANALYSIS IN CEPHALOMETRIC ROENTGENOGRAPHY. *Milton B. Engel, D.D.S., M.S., College of Dentistry, University of Illinois, Chicago, Ill.* Quantification with the cephalometric roentgenographic method has relied upon angular and linear measurements involving certain landmarks. Growth was best indicated by plotting the latter dimension against time. The measurement of areas offers a less limited and more inclusive approach. The planimeter has been used to measure such sharply delineated portions of the film as the cranial area, respiratory area and facial area. Suitable correction for enlargement was then made. The curves obtained with this technic gave a two dimensional assessment of growth.

119. THE PERIODONTAL TISSUES OF THE ALBINO RAT IN VITAMIN A DEFICIENCY. *Irving Glickman and Martin Stoller, Tufts College Dental School, Boston, Mass.* Albino rats were placed on a vitamin A deficient diet one week after weaning and maintained for periods varying from three to four months. The periodontal tissues of these animals were compared microscopically with those of control animals fed the same diet supplemented with vitamin A. Microscopic examination revealed that in the absence of local irritation, the interdental gingival papillae of the vitamin A deficient animals were unaltered and appeared similar to those of the control group. Marginal gingival changes occurred in both groups of animals associated with local accumulations of food debris. The response of the marginal gingivae of the vitamin A deficient animals in the presence of food debris presented the following distinguishing features: A higher incidence of marginal gingivitis which was generally of greater severity than that in the control animals; a tendency toward epithelial proliferation along the cementum and into the corium of the interdental papillae; a tendency toward gingival and lateral abscess formation, and marked epithelial hyperkeratosis. The periodontal membrane and interdental alveolar bone presented no significant alterations in vitamin A deficiency.

120. VARIATION IN SALIVARY PROTEIN CONCENTRATION. *Robert J. Gorlin, A.B., D.D.S., Columbia University, School of Dental and Oral Surgery of the Faculty of Medicine, New York, N. Y.* In the course of investigation of salivary protein by the Tiselius electrophoretic apparatus, the author observed variation in both pattern and mobility of the several components. The variation led to this study of salivary protein to determine whether a constant amount of protein could be obtained by uniformity in collection technic. This was undertaken because the work of Krasnow and Karshan and Tennenbaum and Deakins had demonstrated wide variations in salivary protein values. Mean values in several studies have established salivary protein concentration to be 260 to 300 Mg./100 c.c. of saliva. However, the standard deviations in these studies have varied from 45 to 118, demonstrating the wide range of values. In this study, several variables were made constant, that is, salivary samples were uniform as to amount collected (5 c.c.), time of salivary stimulation (2 minutes), size of paraffin block ($1 \times 1 \times \frac{1}{2}$ cm.), and collection-analysis interval ($\frac{1}{2}$ to 1 hour). Samples were taken from 35 volunteers who had had no breakfast, for purpose of minimizing the effect of protein intake. The effect of smoking and water intake upon salivary protein concentration was not determined in this study. The method of Greenberg, as adapted for salivary protein by Krasnow, was utilized on 1 c.c. samples. A mean value of 280.37 Mg./100 c.c. saliva was obtained. The standard deviation was 65.93 and the standard deviation of the mean was 11.31. It may be concluded from this study that control of the above mentioned factors has no effect upon the variation of salivary protein concentration.

121. THE EFFECT OF TWO SIMILAR DIETS HAVING THE SAME INITIAL PH AND THE SAME GROWTH-PROMOTING ACTION ON EXPERIMENTAL DENTAL CARIES. *Humberto Granados, Johannes Glavind, and Henrik Dam, Polytechnic Institute, Department of Biology, Copenhagen.* Thirty syrian hamsters, 23 days old, were divided into 2 groups (8 males and 7 females in each), being litter-mate distributed, and were reared for 100 days on the following diets. Group I: yellow corn (finely ground) 40 per cent, sugar 20 per cent, corn starch 5 per cent, potato starch 5 per cent, water-washed casein 16 per cent, ether-extracted yeast 8 per cent, salt mixture, 3 per cent, and lard 3 per cent. Each 100 grams of this ration were supplemented with 10 mg. of vitamin E and one mg. of vitamin K. This diet had a pH of 5.51. Group II: yellow corn (finely ground) 40 per cent, sugar 20 per cent, corn starch 5 per cent, potato starch 5 per cent, powdered whole milk 19 per cent, ether-extracted yeast 5 per cent, alfalfa meal 5 per cent, and sodium chloride 1 per cent. This ration had a pH of 5.55. Both groups were given distilled water ad libitum. The growth rate and the health of the animals were the same for both groups. The incidence and extent of carious lesions as measured by Keyes' method (*J. D. Res.* **23**: 439, 1944) were as follows. Group I: average number of carious molars 5.0, average number of carious lesions 5.4, average caries score 1.1. Group II: average number of carious molars 8.2, average number of carious lesions 12, average caries score 2.4. The differences in incidence and extent of caries in the two groups are of a high statistical significance. The higher caries activity in Group II might be explained through the action of three different factors: lactic fermentation of the lactose contained in the powdered milk; impaction of the casein granules of Diet I in the molars' fossae which prevented accumulation of fermentable carbohydrates in the fossae, and protective action against caries of the lard contained in Diet I (Granados, Glavind, and Dam, *Acta Path. et Microb. Scandinav.*, in press). This experiment shows that similar diets with the same initial

pH and the same growth-promoting action can have different cariogenic power when such rations differ in certain chemical components and physical properties.

122. CHANGES IN SALIVARY CALCIUM AND PHOSPHATE AFTER HISTAMINE INJECTIONS. *B. F. Gurney, M.S., and Gustav Wm. Rapp, Ph.D., Loyola University, School of Dentistry, Chicago, Ill.* Changes in salivary calcium and phosphate following intramuscular injections of histamine phosphate in fasting patients and in those fed a test meal were investigated. The object was to determine the role that gastric secretion plays in affecting changes in salivary calcium and phosphate concentrations. This work was undertaken to test the hypothesis that gastric juice secretion has a "reservoir-draining" effect on the salivary calcium and phosphate output.

123. THE ROLE OF OXALATES ON THE INCIDENCE AND EXTENT OF DENTAL CARIES IN THE COTTON RAT, SIGMODON HISPIDUS HISPIDUS. *S. Robert Howell, D.M.D., Carl A. Schlack, D.D.S., B. L. Taylor, D.T.C., USN, and V. J. Berzinskas, D.T. 1, USN, Naval Dental School, Bethesda, Md.* Sixty-six weanling cotton rats were placed on a sugar caries-producing synthetic diet, and potassium oxalate in varying concentrations was added to the drinking water of selected groups. Litter mates served as controls on a comparable diet without oxalates. At the end of the 14-week experimental period necessary to produce the desired degree of dental caries, all rats were sacrificed and their teeth examined for incidence and extent of carious lesions. Statistical analysis of the results ruled out any effect of oxalates on either the incidence or extent of carious lesions. Cellulose added to the diet of one group of rats did not influence the caries picture but was found essential to prevent hair ball formation and mortality incident thereto.

124. THE PREVENTION OF TRICHOBEZOAR IN THE COTTON RAT, SIGMODON HISPIDUS HISPIDUS. *S. Robert Howell, D.M.D., Carl A. Schlack, D.D.S., Clive M. McCay, Ph.D., and B. L. Taylor, D.T.C., Naval Dental School, Bethesda, Md.* Cotton rats, on a synthetic caries-producing diet, showed a mortality rate of about 40 per cent during the experimental period of 14 weeks necessary to produce the desired degree of dental caries. Autopsy indicated that the deaths were caused by trichobezoar formation and an investigation was undertaken in an attempt to control this condition. By adding 10 per cent by weight of cellulose to the diet, the trichobezoars were completely eliminated and all rats lived the full experimental period and remained healthy. Rats fed cellulose showed a significantly greater weight gain than the survivors who were not fed cellulose.

125. THE ARTIFICIAL PRODUCTION OF DENTAL CARIES IN VITRO. *R. A. Hugill, D.D.S., Dental School, University of Toronto, Toronto, Canada.* Experimentally, an attempt has been made to artificially produce a caries lesion in vitro to meet its microscopical characteristics. The research work was carried out under four phases or combination of phases: (a) acid phase, (b) enzyme phase, (c) acid-enzyme phase, (d) bacterial phase. Results would intimate that any acid or any enzyme working independently of one another cannot produce a true caries picture, but a combination of an acid and enzyme reaction on human teeth succeeds to a very high degree. Nonoral organisms incubated in sugar broths reacted on extracted human teeth and produced a microscopical picture not unlike that produced by the acid-enzyme combination. The main objective undertaken in this problem, is to produce a control solution, which is sterile and capable of artificially producing certain phases of the caries lesion.

126. A NEW BIOMETRIC TECHNIC FOR THE STUDY OF PATTERNS OF HEALTH AND DISEASE IN THE ENAMEL OF DENTITIONS. *V. O. Hurme, D.M.D., The Forsyth*

Dental Infirmary for Children, Boston, Mass. Attempts to employ "a tooth" as the unit of measurement in constructing descriptive indices of dental health and disease have not been altogether satisfactory, since the various morphological classes of teeth are neither physically nor temporally equivalent entities. The technics in current use, such as the DMF technic, also violate the law of excluded middle, which is one of the positive rules of thought applied to statistical method. Health cannot be measured in terms of disease, or vice versa, wherefore a good methodology must be based upon a recognition of the antagonistic nature of these two abstractions. The author suggests a dual treatment of data on sound and morbid dental tissue. In terms of conventional mathematical symbolization this can be accomplished by constructing an analytical disease index according to the mathematical laws of indirect variation and a health index according to the laws of direct variation. Since substance (s) and time (t) generally are regarded as the two ultimate variables in any scientific study, it appears reasonable to begin a consideration of tooth conditions by obtaining information on the amount of enamel tissue exposed to the contents of the oral cavity and the length of time of such exposure. If y stands for the importance of the injury risk and x signifies the degree of exposure in terms of substance and time, then, starting with $k = xy$, $y = \frac{k}{x}$ and $x = \frac{k}{y}$. The constant of variation (k) can be given the arbitrary value of 1 until valid objections to this procedure can be discovered. Substituting s and t for x, a disease index can be computed according to the formula $y = \frac{1}{s \times t}$ and a health index according to the formula $\frac{1}{y} = s \times t$, wherein $\frac{1}{y}$ is interpreted as nonimportance of the injury risk or freedom from a pathologic alteration. Utilizing the proposed biometric technics in the study of clinical data on the decay of enamel in the human permanent dentition, it appears possible to prove, conclusively, that the first molars actually are the most vulnerable organs in the "average" mouth.

127. IN VITRO STUDIES OF CARIES OF THE ENAMEL OF THE SYRIAN HAMSTER. *Valerie Hurst, James Nuckolls, Harry E. Frisbie, and Max S. Marshall, University of California College of Dentistry, San Francisco, Calif.* An attempt is being made to produce carious lesions in vitro. First molars of Syrian hamsters are aseptically dissected from their crypts just prior to eruption. After being tested for sterility, they are placed in cultures of the bacteria to be tested. Following incubation, they are fixed, imbedded, and sectioned. Molars which were infected with actinomycetes in broth cultures developed lesions which were remarkably similar to those which occur in hamster molars in situ. The experiment is being continued employing other strains of actinomycetes and, in addition, lactobacilli and other bacteria. About 175 molars will be included in this study, although histologic examination has been completed on only twenty of these teeth to date. Various-like lesions have been produced in three molars with the same actinomycete strain and similar lesions have been produced in other molars with five different strains of actinomycetes. The pH of the cultures remained around the neutral point. The lactobacilli growing in the absence of dextrose at a neutral pH also have shown a tendency to penestrate the enamel and produce carious-like lesions. The lactobacilli growing in dextrose produce an acid pH of 3.5 to 4.0 in which the tooth enamel is entirely dissolved. The histological picture in these teeth is totally unrelated to caries. To rule out the bacteria's utilization of broth media which may have diffused

into the enamel, two further experiments are being conducted. 1. The molars are being placed directly into washed cell saline suspensions of the organisms in the absence of broth. 2. The molars are being placed into cultures of miscellaneous bacteria not common to the oral flora to determine whether these, too, can produce lesions under the conditions of the experiment. Experiments are in progress using human molar teeth similarly inoculated. The molars used are unerupted teeth which are autoclaved after extraction to render them sterile.

128. THE EFFECT OF SODIUM FLUORIDE UPON THE CALCIFICATION OF DENTIN IN RATS WITH LOW Ca RICKETS. *J. T. Irving, Ph.D., M.D., Medical School, University of Cape Town, South Africa.* The reactions of the dentin of the normal rat's incisor tooth after the injection of NaF are already well known (Schour and Smith, *Tech. Bull. Univ. Arizona* **52,** 1934) and the same changes are seen in rats with high Ca rickets (Irving, *J. D. Res.* **22**: 447, 1943). When NaF is given to rats with low Ca rickets, a fine hematoxylin staining line is formed in the predentin being laid down at the time of the injection. However, the incremental growth rate of the predentin is so slow in this condition and calcification so retarded, that in very few rats has this line been seen to blend with the calcifying dentin. In order to accelerate the calcification of dentin in low Ca rickets and to observe more easily the effect of injections of NaF upon this, rats in this condition were dosed once with 27 i.u. of vitamin D after the NaF had been injected. When vitamin D was given in this way, the blood Ca was raised for about four days and then subsided to its previous low level. A calcification response of interglobular dentin occurred continuously throughout the predentin, starting at the calcified dentin and spreading towards the pulp. When the calcospherites reached the F line, they blended with it and appeared to pause in their progress. Then calcification proceeded on the pulpal side of the F line, leaving a narrow irregular zone of uncalcified matrix. In time, as calcification became denser, the F line blended more with the calcified dentin, but the uncalcified zone persisted. The same histological picture was seen after F injection in the few animals in which calcification had not been accelerated by vitamin D. Thus this F reaction is apparently typical of low Ca rickets and not due to the vitamin. In any case, by the time the new calcification caused by vitamin D had met the F line (usually after 6 days), the blood Ca had fallen to its original low level. It will be seen that the effect of NaF upon calcification of the dentin in low Ca rickets is quite different from what occurs in normal animals. The appearance of the uncalcified layer on the pulpal side of the F line is particularly unexpected, since here a hypercalcified zone is usually found.

129. THE EFFECTS OF DIETS CONTAINING SODIUM BISULFITE ON THE UPPER INCISOR OF THE RAT AND ITS SUPPORTING STRUCTURES. *J. T. Irving, Ph.D., M.D., J. P. Weinmann, M.D., I. Schour, D.D.S., Ph.D., Sc.D., and O. G. Fitzhugh, Ph.D., College of Dentistry, University of Illinois, Chicago, Ill., and Division of Pharmacology and Food Division, Food and Drug Administration, Federal Security Agency, Washington, D. C.* This investigation is based on the histologic study of the upper incisors and their supporting structures of 40 male rats of the Osborn-Mendel strain which were kept from the time of weaning for 1 or 1½ years on a balanced diet to which from 0.0125 per cent to 2.0 per cent sodium bisulfite ($NaHSO_3$) was added. Changes in enamel, dentin, and the supporting structures of the upper incisor and in the lacrimal duct could be observed when 0.25 per cent $NaHSO_3$ or more was added to their diet. *Enamel.*—Lack of pigment in the incisors was frequent. The severity of the defect and

its incidence were proportionate to the amount of $NaHSO_3$ and the length of the ingestion of the bisulfite. In no instance was hypoplasia of the enamel found. *Dentin.*—On the other hand, the formation of dentin was severely disturbed, especially on the lingual side of the incisor. Folding of the basal end of the incisor occurred to a varying degree and odontogenic epithelium proliferated into the pulp. In some instances these fingerlike epithelial projections induced dentin formation. *Supporting Tissues.*—The gingiva on the lingual side of the upper incisor was inflamed, deep pockets developed, and the alveolar bone showed osteoclastic resorption. *The Nasolacrimal Duct.*—The ciliated columnar epithelium was replaced by hornified, stratified squamous epithelium. *Conclusions.*—The findings in enamel, dentin, and epithelium resembled those observed in vitamin A-deficient rats. Some of the changes observed in the supporting tissues were similar to changes observed in riboflavin deficiency.

130. Margoid differentiation of the tuberculum dentis. *Th. E. De Jonge, Netherland Academy, Amsterdam, Holland.* Two canines in which the margoid differentiation of their tuberculum dentis revealed the universal character of this anomaly are described and illustrated. The manifestation occurs in all dental elements that deserve consideration in this respect, thus, in the first incisor, the second incisor, and in the canine.

131. Prevention of dental caries. *F. Kostečka, M.D., Professor of Dentistry, University of Prague, Prague, Czechoslovakia.* Dental caries is in its first stage a complicated physical-chemical process which attacks diffusely the healthy surface of the enamel. Not only the fluorine in drinking water increases the resistance of teeth to caries, but other substances have a similar value. The saliva protects the enamel by forming an epimineralization layer and remineralization of the affected area.

132. Odontomes. *F. Kostlan, M.D., Faculty of Dentistry, University of Prague, Prague, Czechoslovakia.* Nine cases of odontomes are described. They were geminated composite and compound odontomes with no subjective disturbance, though in a few cases the patients had symptoms similar to those of difficult eruption, suppurative inflammation, and local osteomyelitis. From a genetic point of view the histological findings were in accordance with the theory of Jesenský and Neuwirt, showing the hard odontomes to be hamartomas, namely, a disturbed composition of the dental tissues and no actual blastomas, because their growing ceases when the dentification of the embryologically preformed tissues is finished. In the disorganization of the tissues the epithelium seems to have the leading part.

133. Internal granuloma. *J. Kostlan, M.D., Faculty of Dentistry, University of Prague, Prague, Czechoslovakia.* Histological examination of four cases of internal granuloma in which the dentin has been partly replaced by osseous tissue is reported.

134. Sound absorption as a measure of tooth mobility. *R. S. Manly, Tufts College Dental School, Boston, Mass.* A signal generator and a home record cutter were assembled to vibrate a short rod at frequencies ranging from 20 to 12,000 cycles per second. A phonograph pickup, amplifier, and decibel meter were employed to measure the amplitude of the vibration of the wire. This equipment was employed to study sound absorption of teeth in situ. Preliminary experiments were carried out on teeth with tape, rubber, and plastic root coverings, and with the roots set into dental stone. There were resonant peaks but these were not affected by the firmness of attachment to the stone,

Instead, a greater mobility of the teeth was disclosed by a lessened damping in the range of 1,000 cycles and 2,000 to 4,000 cycles. When sound absorption at 1,000 cycles was compared with hand estimation of tooth mobility on periodontal patients, a fair degree of correlation was obtained. This seemed to establish the principle of measurement but the equipment requires further improvement.

135. EOSINOPHILIC GRANULOMA. *Z. Mézl, M.D., and F. Škorpil M.D., University of Prague, Prague, Czechoslovakia.* A 19-year-old patient presented with loosened and much denuded second incisor teeth, though the gums were but slightly inflamed. Between the upper and lower molars there was a cleft about 1 cm. in the occlusion. The roentgenogram showed osteolytic areas in the mandible but not in other bones. Medical examination had a negative result. The biopsy showed an eosinophilic granuloma. The patient was treated by tooth extraction and roentgenotherapy but two years later, there was a return of the disease and all his teeth were lost. Specific granuloma was found in periodontium, periodontal membrane, in cementum, and dentin, even in the dental pulp. When the teeth were extracted, the lesions in the mandible recovered.

136. CLASSIFICATION OF THE ARTICULATION FOR PERIODONTAL PURPOSES. *Z. Mézl, M.D., University of Prague, Prague, Czechoslovakia.* The articulation of the teeth is classified as follows: First group—the occlusal planes of the upper and lower dentures are regular and fit into one another. Second group—One of the occlusal planes is irregular and does not fit into the other. Third group—both occlusal planes are deformed. The teeth articulate only in places of deformity. Fourth group—large sets of teeth do not articulate properly, open bite. For each of the four groups, a way of artificial grinding of the teeth is described. The author applies the rules of Hanau and tries to establish a gliding articulation.

137. PRELIMINARY INVESTIGATION OF THE EFFECT OF FOOD PARTICLE SIZE ON THE PERIODONTIUM OF THE HAMSTER. *David F. Mitchell and Kanwar L. Shourie, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Thirty-four weanlings were distributed by litter mates into a control group (I, 6 ♂♂, 6 ♀♀) and an experimental group (II, 11 ♂♂, 11 ♀♀). All animals were maintained in pan-bottom cages without bedding for 168 days. Purina laboratory chow was fed to the controls, and the same diet, ground to pass through a 20-mesh screen was given to Group II. The percentage distribution of the diet which passed through screens up to 150-mesh was recorded.

A survey of the upper jaws of all living animals was made, and representative groups (18 animals) were sacrificed and examined under magnifications up to ×30. The jaws of a ♂ and ♀ from each group were studied histologically. There was no generalized periodontal disease. Nine animals exhibited localized lesions associated with subgingival accumulations or impactions of food and hair. There was no demonstrable difference in the type or degree of periodontal disease in the two groups.

138. THE EFFECTS OF A CARIES-PRODUCING DIET INITIATED AT VARIOUS STAGES OF PRE- AND POST-NATAL DEVELOPMENT OF THE HAMSTER. *David F. Mitchell and William G. Shafer, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Eleven pregnant females were placed into categories distinguished by the pre- or post-natal age at which they or their offspring were started on a caries producing diet (CPD). All received Purina laboratory chow (F 18 ppm. by analysis) until the CPD was initiated. The CPD was begun

at intervals ranging from 12 days before delivery to 30 days after birth. Thus all offspring were fed CPD pre- and/or post-natally for 90 days—post-natal age at sacrifice ranged from 78 to 120 days. In general, female caries experience paralleled that of males but at much lower levels. Average scores. *Pre-natal groups:* 12 days, 5 ♂♂, *50*—2 ♀♀, *4;* 5 days, 9 ♂♂, *1*—11 ♀♀, *1;* 2 days, 3 ♂♂, *3*—5 ♀♀, *0.5*. *Post-natal groups:* 6 days, 4 ♂♂, *21*—2 ♀♀, *9;* 14 days, 2 ♂♂, *101*—3 ♀♀, *32;* 30 days, 3 ♂♂, *142*—2 ♀♀, *35*. Excepting the first group, caries appeared to increase as age at initiation of diet (and at sacrifice) increased. The same organizational setup was run with 46 other animals. Fluorine (40 ppm. from NaF) was added to the CPD. No caries was found in any animal after 90-day exposure periods. Frequent enamel fractures were evident in this group.

139. CHEMOTHERAPY AND PENICILLIN IN STOMATOLOGY. *F. Neuwirt, M.D., Professor of Dentistry, University of Prague, Prague, Czechoslovakia.* Indication for penicillin therapy, sometimes in combination with the sulfonamides, are infections in which there is danger of severe sepsis and its complications. These cases require hospitalization. The practician can, by well-dosed and timed administration of sulfathiazole, prevent many acute or chronic inflammatory processes. Very good results have been achieved by penicillin in actinomycosis, necrotic gingivitis, and noma. One must, however, not forget that penicillin is effective only against the bacterial factor so that to prevent relapses, the decreased local and general resistance should be treated too. In the prevention of postextraction osteitis, the local application of both penicillin and sulfonamides proved to be useful. The best method is to treat the wound immediately after the extraction by putting the powder directly into the alveolus so that the newly formed blood clot should be under its protective action from the start. In cases of fully developed postextraction osteitis, the local application of sulfonamides failed to be effective, but penicillin was of value. To prevent the spreading of infection by surgical procedure, the patient should be prepared by oral administration of sulfonamides and parenteral administration of penicillin. The proper choice of antibiotics and chemotherapeutics should be based on a bacteriological investigation as there are microbes resistant to them. Local application of penicillin was successful in many suppurative processes. One may inject the penicillin into the pus-containing tissues, that is, into abscesses. The effect is better when using a high concentration.

140. THE MAGNESIUM CONTENT OF DENTIN. *Isaac Neuwirth, College of Dentistry, New York University, New York, N. Y.* The distribution of magnesium in dentin was studied by staining ground sections of teeth with selective color reagents and by analyzing gravity fractions of the powdered tissue. The findings are compared with the distribution of other constituents, and their bearing on the function of magnesium in the calcification process is considered.

141. GIANT CELLS IN THE GINGIVA. *Balint Orban, M.D., D.D.S., School of Dentistry, University of Illinois, Chicago, Ill.* In chronic granulation tissue of the gingiva, giant cells are frequently seen, mostly of the foreign body giant cell type. In cases of specific inflammation, such as tuberculous, the Langerhans' type of giant cell is found. In cases of gingivitis in pregnancy, large multinucleated cells have been found in the walls of capillaries. In a case of desquamative gingivitis in a patient who had received large doses of estrogenic hormone and exhibited a carcinoma of the breast, multinucleated cells could be found in the epithelium, mostly in the germinative layer and also in the prickle cell layer.

142. Surface characteristics of the gingiva. *Balint Orban, M.D., D.D.S., School of Dentistry, University of Illinois, Chicago, Ill.* The gingiva may be divided into free and attached gingiva which are separated from each other by a fine line, the free gingival groove. The attached gingiva is characterized by stippling which is due to elevations, caused by connective tissue fiber bundles and small depressions in the epithelium. The differences between the gingiva and the alveolar mucosa are discussed, as is also the interdental papilla and the marginal gingiva.

143. A study of the supporting structures of the teeth and other tissues following alloxan injection. *James C. Page and William E. Hahn, School of Dentistry, University of Maryland, Baltimore, Md.* Thirty-six male albino rats averaging 202 grams in weight were divided into three groups of twelve rats each; each animal was injected with 175 mg. of aloxan per kg. of body weight according to the preinjection starvation technic. A fourth group of twelve rats was used as controls. The first group was carried for 8 weeks and then sacrificed, at which time microscopic slides were made from sections of the mandible, pancreas, ribs, liver, and kidneys. The same procedure was repeated with the second group at 12 weeks and with the third group at 16 weeks. Four control animals were sacrificed with each experimental group. Individual blood sugar level determinations were made on all animals at regular intervals every other week. Weight determinations on all animals were made at the same time. Of the eleven surv. ng animals in the first group, six presented a blood sugar level above 200 mg. per cent at the end of 8 weeks. There were five such animals of ten surviving in the second group at 12 weeks, and three out of ten surviving animals in the third group at 16 weeks. During the experimental period, the average individual blood sugar levels ranged from 154 mg. per cent in the lowest animal to 519 mg. per cent in the highest animal. Following injection all animals maintained in a hyperglycemic condition presented all the primary clinical symptoms of polyuria, polydipsia, and polyphagia that accompany diabetes mellitus. Histological examination of the tissues taken from the experimental animals revealed essentially the same processes in all diabetic animals regardless of the time of sacrifice. Observations made upon studying the microscopic slides are as follows: 1. The alveolar bone, periodontal membrane, dental pulps, and gingival tissues of the hyperglycemic animals in all three groups were normal in appearance and corresponded histologically with the same structures in the control animals. 2. Degenerative nuclear changes were evident in individual cells in the beta cell region of the pancreatic islet tissue in the hyperglycemic animals. 3. The cells of the liver and kidneys of the hyperglycemic animals showed cloudy swelling. 4. There was an extensive porosis present in the cells of the glomerular tubules of the kidneys in the region of Henle's loop in the diabetic and, to a lesser extent, in the nondiabetic animals.

144. Histopathology of periodontosis. *Č. Parma, M.D., University of Prague, Prague, Czechoslovakia.* The work starts with histological investigation of supporting ligaments of the tooth which are separated into two systems, the periosteal and the intra-alveolar. The origin of circular ligament is explained and the changes which take place during the tooth eruption and the involution of the alveolar bone are described. It is shown that the epithelium, under physiological conditions, penetrates only to such a depth as the circular ligament will permit. The histology of marrow of the alveolar bone and the resorption of bone are revised. In detail are investigated the alterations of tooth-supporting tissues during the involution periods of the alveolar

bone and a trias of involution is described: osteoporosis, narrowing of periodontal membrane, and hypertrophy of cementum. As to the periodontosis, the author distinguishes a number of them but so far he has examined 6 cases of periodontosis tuberculosa and ascertained a tendency for fibrous changes in the marrow, inertia of mesenchymal elements and the trias of involution. Inflammatory changes always give an impression of a secondary, saprophytic process.

145. TRAUMATIC GINGIVITIS. *Č. Parma, M.D., Faculty of Dentistry, University of Prague, Prague, Czechoslovakia.* Traumatic gingivitis and periodontitis are to be divided into three groups according to the cause of the disease, namely, malocclusion, dehiscence of the vestibular layer of the alveolar bone, and improper restorative dental work. Though malocclusion and faulty dental work are known to cause food impaction or direct injury of the gingiva, the dehiscences of the alveolar bone have not yet been described in relation to gingivitis. They are found on anomalous teeth (rotation, inversion, etc.) and the author has a collection of skulls of children showing little or no alveolar layer on the vestibular aspect of some front teeth, due to the imperfect evolvement. Where there is no bone, the attachment of the gingiva to the tooth through the epithelium is not firm. The gingival margin soon gets loose and inflamed. In course of time the injuries by food and the inflammation cause the gingiva to shrink down.

146. OCCUPATIONAL DISEASES OF THE TEETH. *Č. Parma, M.D., Faculty of Dentistry, University of Prague, Prague, Czechoslovakia.* There is a qualitative and a quantitative method for examination of occupational diseases of the teeth. The former makes the diagnosis by excluding the nonoccupational conditions on the teeth and by finding that (1) the changes occur in great number, that (2) every new employee gets them after a certain time and that (3) the suspicious noxa, according to the experience, is liable to cause the changes or can develop them in experiment. The latter method uses only quantitative differences in some pathological symptoms and is good for special examinations only. The author distinguishes four groups of occupational diseases: (a) mechanical, (b) from dust, (c) from direct effect of the chemicals, and (4) from intoxication with industrial noxae. The mechanical injuries or abrasions are associated with a certain shape of human dentures. They are typical, but unusual. Diffuse attrition of the teeth has to be revised. There is no special periodontosis or periodontitis of musicians. The loosening of the teeth in workers with pneumatic hammers may be severe. From conditions caused by dust, only cases in which the soft covering of the teeth does not incrust are acknowledged by the author as occupational diseases. There are marginal gingivitides or periodontitides and caries of the tooth necks. Hard covering of the teeth does not damage the tooth, though the gingival margin can be irritated and inflamed in an unspecific way as by calculus. This hard covering can be prevented, whereas the soft films of bakers, etc., cannot be completely removed with tooth brushing and normal tooth paste. Chemical erosions of the teeth are not so great as forty years ago and are capable of spontaneous reparation during the periods between the work. Occupational intoxications are caused mostly by heavy metals. Of the other materials, benzine and CO were examined. So far the author has not found an occupational periodontosis.

147. THE EFFECT OF COMMERCIAL GROWTH COMPLEX UPON THE ORAL STRUCTURES OF NORMAL RATS. *Burton Robert Pollack, Sylvia L. Pollack, William E. Hahn, Schools of Medicine and Dentistry, University of Maryland, Baltimore,*

Md. It was the object of this experiment to note the changes produced in the oral tissues in experimental giantism. Mature female rats were selected for the experiment. Intraperitoneal injections of Growth Complex (1 to 4 rat units daily) were administered to supplement the normal secretion of the growth factor by the anterior lobe of the pituitary body. To facilitate the osseous studies, injections of alizarine red S (75 mg./kg. of body weight) were made. Individual weight records were computed daily, and at the end of the fifty-sixth day, the animals were sacrificed. Gross and microscopic studies were made of the tongue, gingival tissue, submaxillary glands, decalcified mandible, whole mandible, and ground sections of the incisors. The following results were noted: 1. The average weight gain of the experimental animals was 16.4 grams more than that of the control group. 2. The experimental group showed no qualitative changes in the teeth, gingival tissue, tongue, or submaxillary glands. 3. Measurements of the average daily rate of dentin deposition, length of incisors, and the rate of formation of new bone at the growing points of the mandible revealed an over-all increase in the experimental group as compared with the measurements of the control group. During the course of the experiment it was also noted that a marked diuresis resulted from the administration of the growth complex.

148. A SIMPLE METHOD FOR ESTIMATING VITAMIN A SATURATION. *Gustav Wm. Rapp, Ph.D., and B. F. Gurney, M.S., Loyola University, Chicago, Ill.* The basis of this estimation lies in a relation between the dark-adaptation time of a previously illuminated eye and the vitamin A saturation state of the body. Briefly, the apparatus consists of a light-tight partitioned box which allows (a) the illumination of the eyes and alternately (b) the viewing of bright-line geometric figures of graded light intensity. The degree of saturation is determined from the rate of dark-adaptation before and after a massive dose of vitamin A.

149. DECIDUOUS TOOTH SHEDDING IN DOGS. *J. S. Restarski, D.D.S., M.D.S., College of Dentistry, Loyola University, Chicago, Ill.* Resorption of the deciduous teeth observed in two five-month-old dogs differed from the apparently normal process in humans. During shedding of the deciduous teeth in humans, the osteoclastic activity procedes in the loose connective tissue around the root, while the pulp plays a passive role. Resorption in the dogs, in addition to being observed on the surface of the root in close proximity to the erupting permanent teeth, was also active within the pulp chamber and pulp canal in the presence of normal appearing pulp tissue. At some points the osteoclasts were interspersed among the odontoblasts lining the predentin.

150. AN ATTEMPT TO PRODUCE GINGIVAL HYPERPLASIA IN THE ALBINO RAT BY THE ADMINISTRATION OF DILANTIN SODIUM. *William G. Shafer, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* In the first study, 36 animals were used: 12 controls received ground Purina laboratory chow; 12 animals received this diet plus a daily dose of Dilantin Sodium (Parke, Davis & Co.), corresponding to human therapeutic levels; and 12 animals received twice this dose. After 14 weeks, no gross or histological evidence of gingival hyperplasia could be detected. A recent publication reported the production of dilantin gingival hyperplasia in ferrets (King, J. D., *Brit. Dent. J.* **83**: 148, 1947). It appeared that the diet used might have been low in protein, so a second study was carried out here using 48 albino rats to test this as a possible predisposing factor. Group I received a soft diet consisting mainly of bread and in addition 10 per cent casein plus 10 mg. per kg.

of body weight of dilantin per day. Group II received the same diet without casein plus the same amount of dilantin. Group III received the diet with casein plus 500 mg. per kg. of body weight of dilantin per day. Group IV received the diet without casein plus the same amount of dilantin. Group V and VI received the diet with and without casein, respectively; neither group received dilantin. After 13 weeks, no gross evidence of gingival hyperplasia was observed.

151. CALCIUM CONTENT OF THE DIET AND PERIODONTAL DISEASE IN HAMSTERS. *K. L. Shourie, S. W. Leung, and D. F. Mitchell, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* Seventy animals, 22 to 33 days old, were distributed by litter mates into 5 groups (6 ♂ ♂, 8 ♀ ♀ each). For a basal 10 days, all animals were fed a soft synthetic diet deficient in Ca (.007 per cent) but otherwise nutritionally adequate. Then Ca, as gluconate, was added as follows: Group I, 0.05 per cent; II and III, 0.2 per cent; IV and V, 1.2 per cent. Fluorine, 20 ppm. as NaF, was added to the water of III and V. After 142 days, the 54 survivors were sacrificed and examined for the presence of periodontal disease and calculuslike deposits, using magnifications up to ×30. Group I suffered the highest mortality and least gain in weight. No significant differences in these characteristics existed among the other groups. The premature loss of half the animals of Group I makes a comparison of periodontal findings of questionable value. Nevertheless, the impression was gained that the animals on the high Ca diet (IV and V) had somewhat less periodontal disease than did those on the medium and low Ca diets. NaF, as added, had no apparent effect on the periodontal findings.

152. STUDIES OF THE RELATIONSHIP BETWEEN MALOCCLUSION AND DENTAL CARIES IN CHILDREN IN INDIA. *Kanwar L. Shourie, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* One thousand sixty-seven school children from Lahore, India, were examined for malocclusion and dental caries. The malocclusion was recorded according to Angle's classification. Incidence of malocclusion was found to be 49.3 per cent. The evaluation of relationship between dental caries and malocclusion suggests that there exists a direct relationship between malocclusion and dental caries.

153. IS THERE ANY RELATIONSHIP BETWEEN THE INCIDENCE OF PERIODONTAL DISEASE AND DENTAL CARIES? *Kanwar L. Shourie, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* The antagonism between dental caries and periodontal disease has been suggested by some workers, but very few surveys have been carried out to substantiate or prove otherwise this view. In an attempt to find out whether any correlation exists between periodontal disease and caries, 1067 boys of 13 to 16 years of age were examined for dental caries and periodontal disease. The periodontal disease was recorded as normal +, ++, +++. The results which were statistically examined do not suggest any correlation or antagonism between the incidence of dental caries and periodontal disease.

154. BLOOD STUDIES IN HAMSTERS INGESTING SODIUM FLUORIDE SUPPLEMENTS. *Kanwar L. Shourie and Helen McRae, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* The effect of the addition of 50 ppm. of fluorine to water on the hemoglobin concentration of blood was studied in hamsters. Two groups of hamsters were kept for 60 days on the following diet: whole wheat flour, 30 per cent; dry milk powder, 30 per cent; corn starch, 20 per cent; sugar, 15 per cent; alfalfa, 4 per cent; sodium chloride, 1 per cent. One group (9 animals) was given distilled water and the other

(10 animals) received 50 ppm. fluorine as sodium fluoride in drinking water. Blood in most cases was obtained by heart puncture. Hemoglobin was estimated by the oxyhemoglobin method. The results obtained indicate that 50 ppm. of fluorine did not affect the hemoglobin concentration of the blood of hamsters raised under these conditions.

155. THE POSSIBLE EFFECT OF BETEL CHEWING ON THE INCIDENCE OF DENTAL CARIES IN INDIAN CHILDREN. *Kanwar L. Shourie, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.* The practice of chewing betel nuts containing betal nuts and spices is as common amongst certain populations in India as is the smoking habit in the States. Almost all classes and ages of people in some parts of India chew betels, while in other parts (Lahore) the practice is not so prevalent. In Bhopal the children start chewing betals as early as 3 to 4 years of age. Four hundred eighty-seven children were examined for dental caries in Bhopal, and the results were compared with those of 1708 children from Lahore. The percentage of children free from caries in betel nut chewing areas was 59.7 as compared to 39.1 obtained in Lahore. The higher percentage of freedom from caries in betel chewing areas may be due to leveling off of some of the fissures and pits in teeth by the abrading action of hard betal nut pieces during chewing.

156. ORTHODONTIC THERAPY OF THE UPPER FIRST INCISORS WITH DEFORMED ROOTS. *J. Simek, M.D., Faculty of Dentistry, University of Brno, Czechoslovakia.* Two cases of deformed upper first incisor with bent root are described. In spite of the fact that in both cases the age of the patients was over 8 years, the therapy was successful.

157. DENTAL ENGINEERING AS IT APPLIES TO INLAYS, BRIDGES, AND PARTIAL DENTURES. *Edwin S. Smyd, D.D.S., Detroit, Michigan.* A new and original approach to inlay and prosthetic problems will be presented. The engineering principles involved in individual and prosthetic inlays will be considered. Engineering terms will be defined and experimental verification of the principles which apply will be demonstrated. A method of constructing precise indirect inlays based on the above concepts will be shown by slide presentation.

158. THE USE OF THE RADIOAUTOGRAPH FOR STUDYING THE RELATIVE RADIOACTIVITY OF DENTAL MATERIALS. *Reidar F. Sognnaes and James H. Shaw, Harvard School of Dental Medicine, Boston, Mass.* Thin ground sections of teeth from monkeys and dogs into which radioactive phosphorus had been injected were prepared by the plastic embedding method of Sognnaes (*Anat. Rec.* **99**: 133, 1947). Fast, panchromatic, antihalation film of moderate contrast was found to be most suitable. The first radioautograph of any ground section was made by a sufficiently long exposure that all parts of the film in contact with the tooth had been adequately exposed. A guide to the length of exposure necessary was obtained by rough determination of the radioactivity of the section with a Geiger-Müller counter. In this way a rough evaluation of the relative radioactivity of the various parts of the tooth was obtained. Then, using the first radioautograph as a guide, the very radioactive regions of the tooth which, because of their high radioactivity, caused a halo effect beyond the limits of the actual region could be removed. By the use of a dissecting microscope and fine dental drills, highly radioactive regions such as the predentine and surface enamel could be removed completely without the loss of less radioactive regions. When this operation had been completed, the remaining regions on the section could be used for a second radioautograph which repre-

sented the relative radioactivity of the remaining regions. In this case, a much longer exposure is necessary in order to get the optimum exposure of the emulsion of the film. Thus a composite impression of the relative radioactivity of the varying regions of the teeth was obtained by superimposing first and second radioautographs.

159. CERVICOFACIAL ACTINOMYCOSIS TREATED BY PENICILLIN. *J. Soldán, M.D., Olomouc, Czechoslovakia.* The case originated in direct infection of a facial wound with vegetable filaments. Penicillin in total dose of 3,100,000 U in combination with sulfathiazole healed the disease in twenty-three days.

160. GINGIVAL EPITHELIUM IN ERUPTION. *F. Wassermann, Zoller Memorial Dental Clinic, University of Chicago, Chicago, Ill.* The continuously erupting teeth of the guinea pig are well suited for studies on the role of the gingival epithelium in eruption. When the periodontal fibers break from their attachment to the enamel as they move toward the epithelium, they are prior to the detachment completely surrounded by the epithelium. Thus the epithelium does not just occupy the space opened by the receding fibers. After the detachment the fibers dissolve beneath the epithelium. Also, the periodontal cartilage passes by the epithelium in eruption. At certain places the unusual direct relationship of epithelium and cartilage is established. Where the epithelial cells lie directly on the cartilage, chondriolysis is taking place with the typical signs at the contact face. In cases with damaged epithelium, such as, in scorbutus, no chondriolysis is found, and the dissolving of the periodontal fibers is delayed. These observations suggest strongly the active participation of the epithelium in eruption, probably by enzymes which act on the cartilage ground substance and the cementing substance of the collagenic fibers.

161. HISTOPATHOLOGY OF ENAMEL CARIES. *Jan Wolf, M.D., and Fr. Neuwirt, M.D., Faculty of Dentistry, University of Prague, Prague, Czechoslovakia.* The shadowed collodion replica method of Jan Wolf has been used since 1939 to study the beginning of enamel caries. Out of the very great histological collection, only twenty-one most instructive microreliefs were chosen to eludicate the morphological changes of enamel through caries just starting. The enamel caries starts always as a diffuse process with no regard to the histological structure of the enamel. It begins on a relatively large surface of enamel and, as a rule, there are several affected areas at the same time. Changes never have been found which would prove Gottlieb's concept of lamellae and cracks to be the highway of bacteriological infection and tissue decay. Comparing the findings in incipient caries with similar findings caused by other factors, the authors have found that the microreliefs of incipient caries and of enamel etched by some acids are the same. In both cases the interprismatic substance is resistant and the ends of prisms are hollowed. Thus the enamel caries starts as a decalcifying process of the prisms by some acids, diffusely, and on everal areas of the predisposed place. Arrested enamel caries was always found to be covered by calcic layers, epimineralization. This calcic covering of affected area may be limited to this area only, though it may be spread over a larger area. The epimineralization coat is a barrier preventing the partly decalcified tissue below from further destruction. In the calcic coat were found filament microbes (as in calculus) which, as was proved in another study published in 1943, facilitate the precipitation of the calcic salts. Epimineralization can also be studied on artificially damaged enamel surface (etched by nitric acid, scratched by a sharp instrument). It makes the damaged area smooth, or fills it completely. Remineralization in some

depth of the enamel was studied in ground sections, also by the replica method of Jan Wolf. The transparent enamel proved by the replica method to be hypercalcified, showing not the usual good distinction of prisms, sheaths, and interprismatic substance. The authors tried to prove that the calcium salts of the hypercalcified zones in enamel caries are taken chiefly from the saliva. In the undermining enamel caries, the superficial intact portion is hypercalcified, though the endogenous and pulpal influence is out of question. The adjacent parties of the enamel caries are slightly decalcified, a fact little known. This decalcification is due to the same noxa which causes caries or to acids originated out of caries.

162. PREPARATION PROCESS OF THE ENAMEL SURFACE IN NATURAL AND ARTIFICIAL DEFECTS. *Jan Wolf and Fr. Neuwirt, Faculty of Dentistry, University of Prague, Prague, Czechoslovakia.* The shadowed collodion replica method which Jan Wolf has applied for more than 10 years is used for the study of the reparation of the enamel defects. It makes it possible to study the most subtle details in microrelief in vivo. Enamel surface, etched with nitric acid, shows denuded prisms. But a few days afterward, the etched place is covered with a homogeneous calcic layer, limited to the extent of the affected area. The speed of building a calcic layer differs in individuals, but does not depend on the vitality of the tooth. The pulp does not participate on the building of a calcic layer nor does the periodontal membrane as has been proved by experiments, especially on natural tooth crown attached to the prosthesis. The calcium salts do not originate from dissolved enamel because enamel scratched by mechanical means causes the calcic layer to be formed in the same way as enamel etched with acids. Thus the calcium salts must be taken from the saliva. Where the tooth is worn off by attrition, there is also a calcic layer. On the sheltered places of the tooth the calcic layer is present too, but it is very thin. The cracks and the lamellae of the enamel are filled up with calcium salts and in this way the dental caries, in so far as it is caused by food retention and microbes, may be prevented. The cause of the precipitation of the calcium salts from the saliva on the tooth surface is manifold, but there is surely an affinity of these salts to the enamel. A stimulation of this precipitation by the pulp or periodontal membrane has not been observed. As the permeability of the enamel for some fluids is known, a penetration of the calcium salts in some depth of the enamel may be supposed. The authors come to the conclusion that the saliva, supplying the calcium salts, plays an important part in hardening the enamel and covering it with the calcic layer. In this way it prevents dental caries and a fast attrition of the tooth by masticatory pressures. Incipient caries may be healed by remineralization of the affected tissues.

163. A CLINICAL AND THERAPEUTIC APPROACH TO THE STUDY OF ORAL MUCOUS MEMBRANE LESIONS OF PROBABLE METABOLIC ORIGIN. *Daniel E. Ziskin, D.D.S., Maxwell Karshan, Ph.D., George Stein, M.D., D.D.S., Herbert Silvers, D.D.S., Faculty of Medicine, Columbia University, New York, N. Y.* The purpose of this study was to investigate the possibility of metabolic disturbances playing an etiological role in certain chronic oral mucous membrane lesions. Twenty-three females and seven males, ranging in age from 8 to 73 years, were studied. The routine procedures included history, kodachrome photographs and biopsy of area or areas involved, complete blood chemistry, basal metabolism test, analysis of a week's diet, a physical examination, and psychiatric interview. Therapy was then instituted, and the foregoing were renewed from time to time. The treatment was based on earlier studies of oral mucous lesions in humans and laboratory animals. These were concerned with the keratinizing

effect of the sex hormones, the hyperkeratinizing effect of vitamin A deficiency, the formation of ulcers and hyperkeratinization in pantothenic acid deficiency, atrophy in protein deficiency, vesicle formation in biotin deficiency, and the effect of lecithin on steroid metabolism.

Estrogenic and androgenic preparations, vitamin A, vitamin B complex, lecithin, panthothenic acid, and biotin were given either singly or in combination, depending on the type of lesion present. It was found that the histopathological appearance of the tissues did not always follow the commonly accepted pattern of textbook lesions descriptions of oral leukoplakia, lichen planus (without accompanying skin lesions), or chronic desquamative stomatitis. Hence, a re-evaluation is indicated. While no definite conclusions can as yet be drawn from these studies, therapeutic benefits have been derived in some cases with the use of these agents. Findings at present indicate that vitamin A and lecithin in oral leukoplakia, the sex hormones in desquamative stomatitis, and a combination of vitamin A and the sex hormones in cases of so-called oral lichen planus caused some alleviation of clinical and histological findings. Psychoneuroses, present in most of these patients, may have a bearing on etiology.

XII. Executive proceedings and Register of Newly Elected Officers and Members

A. Council Sessions

Activities Between General Meetings

By mail ballots the Council selected the time and place of this, the twenty-sixth general meeting; nominated candidates for the 1948 official ballot form; approved a requirement of at least five members for the formation of a new section of the American Division; acted favorably on the petitions of members to form sections in Oregon, Washington, and the City of Mexico; approved the remission of dues in the cases of W. F. Lasby and F. C. Waite; approved a budget of not more than $500.00 for the operation of the office of the Secretary-treasurer for the 1948 calendar year, to be distributed as follows, secretarial services—$150, printing—$140, postage—$100, annual meeting—$50, miscellaneous including travel—$60; and received various resolutions and communications which were referred to the officers and the Board of Editors for their consideration and disposal.

Friday Afternoon Session, June 18, 1948

Received the following financial report of the Secretary-treasurer and authorized the addition of $5.47 to the 1947 budget disbursed in excess of the previously approved $500:

Total receipts for the 1947 calendar year		$2,011.39
Disbursements for Secretary-treasurer's expenses	$ 505.47	
Collections transferred	1,248.00	
Total		1,753.47
Surplus		257.92
On hand as of Jan. 1, 1947		1,840.85
On hand as of Dec. 31, 1947		$2,098.77

Distribution of balance on hand, Dec. 31.

General Fund	$ 878.44
Journal of Dental Research Share	422.35
Dental Science and Dental Art Fund	794.88
Chicago Section	3.00

Combined Report of Secretary-treasurer and Business Manager as Submitted to the Collector of Internal Revenue

Total Income		$10,168.70
Expense		
Printing	$8,299.05	
Clerical	2,639.74	
Stationery, etc.	135.03	
Mailing	225.24	
Total		$11,299.66
Deficit for 1947		$1,130.96

Special William J. Gies *Journal of Dental Research* Fund.

On hand in bonds and savings account, Jan. 1, 1947	$1,435.98
Additions, all interest	33.78
On hand, Dec. 31, 1947	1,469.76

These reports were approved and publication in the proceedings ordered.

The report of President Hodge on the resolutions and communications bearing on the current publishing procedure for the *Journal of Dental Research* was received. First informally, point by point, and then by a formal unanimous vote, the statement dealing with these resolutions and communications issued by the general officers under the date of April 24, 1948, was approved. The essential features of this statement are:

The officers find no support for claims that have been made to the effect that the *Journal of Dental Research* has been sold to the C. V. Mosby Company for the purpose of commercial exploitation. They hold to the belief that the constitution confers sole and undivided authority on the Board of Editors to conduct the *Journal of Dental Research* for the International Association for Dental Research. They find no constitutional support for the hypothesis that decisions of the Board of Editors must be ratified by the Council or the Association before they become operative. They believe that the contract with the C. V. Mosby Company is legal and binding and can be changed only by mutual agreement of that Company and the Board of Editors. They are of the opinion that the Publication Committee and the Board of Editors have made annual reports in complete compliance with the constitutional directive, and that, for the last three occasions at least, these reports have indicated dissatisfaction with the then current publication plan. They are certain that these reports have been formally approved and usually with favorable commendation of the Publication Committee. They anticipate that appropraite reports will be forthcoming at the coming meeting of the Association in June, and that, at this time, it will be in order to open up the matter for further discussion and such action as may be taken within the limits permitted by parliamentary rules and the constitution.

Supported by a unanimous vote the submission to the Association of an amendment to the constitution authorizing annual dues to the amount of $10.00 per year per member. Also authorized the appointment of a committee to prepare a draft for a revision of the constitution for submission to the Association at the 1949 annual meeting.

By unanimous vote ordered that all checks for the disbursement of Association funds in the custody of the Secretary-treasurer be signed by at least two of the general officers in the following list: Secretary-treasurer, President, and President-elect.

Authorized the program committee to schedule a two and one-half day program for the 1949 general meeting and the appointment of a committee by

the President to report on plans for the time and place of the 1949 general meeting and to confer with the appropriate agencies of the American Association of Dental Schools and the O. K. U. Honorary Fraternity in order, and if possible, to secure a satisfactory coordination of the meetings of these three associations.

Directed the Secretary-treasurer to communicate with Dr. William J. Gies in reply to this letter regretting his inability to attend this meeting, expressing the disappointment of the Council and members and their very cordial greetings to the Association's founder.

Sunday Morning Session, June 20

By unanimous votes instructed the Secretary-treasurer to list only one Council candidate for each office on the official 1949 ballot form, and, in reporting Council votes, to recognize any number of votes clearly in excess of one-half of the Councillors returning ballot forms within a reasonable time as the Council majority, and further, in reporting votes on the nominations for the general officers, to list totals only, without revealing the votes of individual Councillors.

Received the reports of the Board of Editors and the Publication Committee, and specifically the following directive passed by the Board of Editors after long and careful consideration:

The Publication Committee is instructed to explore the possibilities for replacement of the $1,800.00 now received as a royalty from the C. V. Mosby Company by a suitable substitute from some other satisfactory source before December 31, 1948; and the Publication Committee is authorized to modify the contract (with the C. V. Mosby Company) accordingly by mutual consent of the Publication Committee, as agents for the International Association for Dental Research, and the C. V. Mosby Company.

These reports from the Publication Committee and the Board of Editors were ordered approved without discussion or comment by a large majority.

Authorized the appointment of a committee to establish a Dental Science and Dental Art Award as per the recommendation of the Chairman, H. B. G. Robinson, of the Dental Science and Dental Art Fund and the discharge of the old committee.

Set the dues for the 1949 calendar year at the rate of $5.00 per year per member for those residing in North America, and $1.00 for all others except those whose dues are remitted by due process or special Council action. Of each $5.00 item collected ordered $1.00 be set aside and appropriated for the general expenses of the Association and $4.00 disbursed in the form of block subscriptions to the C. V. Mosby Co. for the *Journal of Dental Research* to supply those entitled thereto. Also approved the appropriation of an additional sum of not more than $2,000.00 for the conduct of the *Journal of Dental Research* and the expenses of the Publication Committee incurred in that project, if and when such funds are made available. An over-all budget of $700.00 was authorized for the expenses of the Secretary-treasurer.

Received the report of the tellers and ordered the installation of the newly elected officers at the Sunday Noon Session. (List of New Officers printed on page 781 of these proceedings.) Approved the nominations of 32 candidates for election to membership as complete and in good order for submission to the Association at the Sunday Noon Executive Session. (See page 781 of these proceedings for the list.)

Councillors in attendance at one or both Council sessions (including proxies with credentials): Arnim, Becks, Blayney, Boyle, Brodie, Bryan,

Burrill, Crawford, H. T. Dean, Gurley, Hatton, Hill, Hine, Hodge, Karshan, Kitchen, McCrea, Mitchell, H. J. Noyes, Speidel, W. F. Swanson, N. O. Taylor, Waugh, Zander. Total, 24.

B. EXECUTIVE SESSIONS

Saturday Morning, First Executive Session

The meeting was called to order by President Harold F. Hodge at 9:05 in the Roof Solarium of the Sheraton Hotel, Rochester, New York, and briefly addressed by him with a cordial welcome for members and guests. The minutes of the Twenty-fifth General Meeting were called for and the following corrections of the proceedings as printed in the Dec. 1947, number of the *Journal of Dental Research* were offered: On page 477 of the proceedings insert the following, beginning just after the period in the third line of the report of the William J. Gies Endowment Fund: *According to this report, $1,183.29 in the form of interest and $249.50 in new contributions have been added to the fund since the time of the last report (6/14/46), a total of $1,432.79. As of the date of June 14, 1947, the total receipts (assets) are listed at $43,647.18. This is net as no expenses have been charged against this fund.* Also begin the following paragraph with this statement: *This was followed by the report of the Association Secretary-treasurer covering funds received from dues and other sources and their routine disbursement.* On motion the minutes were approved as corrected in the printed form from the *Journal of Dental Research*, Vol. 26, pp. 477-481.

The Secretary-treasurer's financial reports were read, as printed in the Council minutes, and ordered approved.

The deaths during the past Association year of members L. R. Johnson, J. T. O'Rourke, and C. R. Turner were announced and at the direction of President Hodge the audience stood briefly in memory and honor of their late colleagues.

President Hodge then reported briefly on the year's activities, after which the meeting was adjourned until a convenient time about the middle of the Saturday Afternoon Scientific Session.

Saturday Afternoon, Second Executive Session

The meeting was called to order by Secretary-treasurer Hatton, presiding, who called for the report of the Treasurer of the William J. Gies *Journal of Dental Research* Endowment Committee, Leuman M. Waugh. Dr. Waugh in person, presented the report in considerable detail and urged that every possible effort be made to complete the collection of the principal sum, $50,000.00, at a very early date so that the Committee could transfer the principal to the designated agency and be discharged. He also reported to the effect that he believed that funds could be made available for use in conducting the *Journal of Dental Research* in lieu of income from the endowment until the principal sum was collected in full and transferred to the Association. This report was accepted for publication in the proceedings of this meeting in the *Journal of Dental Research* (p. 779) and the committee and Dr. Waugh most cordially thanked for their activities in collecting and caring for this fund. The meeting was then adjourned until Sunday Noon.

Sunday Noon, Third and Final Executive Session

President Hodge was in the chair. The report of all Council activities was called for and presented by the Secretary-treasurer as printed above. On motion all decisions and acts of the Council were approved, including spe-

cifically, the proposed financial budgets for the remainder of the 1948 year and for 1949. (For the Secretary-treasurer an over-all sum of $700.00 for 1949 routine expenses, and not more than $2,000 for the operation of the *Journal of Dental Research.)*

The reports of the Publication Committee and the Board of Editors were presented by H. B. G. Robinson and J. Frank Hall. (Printed elsewhere in these proceedings, see page 777). On motion these reports were accepted and ordered filed without any discussion. (This specifically included the item concerned with the instructions to the Publication Committee with reference to some substitute for the $1,800.00 royalty from the C. V. Mosby Company.)

The following amendment of Section 1 of Article VIII of the constitution was offered by H. C. Hodge, E. H. Hatton, B. G. Bibby, P. C. Kitchen, and H. B. G. Robinson in order to make it possible to create enough income to prevent future deficits.

Section 1 of Article VII shall be replaced by the substitution of the following statement: *Article VIII, Finances. Section 1: Amount of dues. At each annual meeting of the Association the amount of the annual dues, payable by each member on or before the last day of February of the succeeding year, shall be determined by the Council, and may not exceed ten dollars.*

The following amendment to the By-laws was offered for approval and was adopted by a unanimous vote of all present at this session (attendance over 50).

Subsection 5 of Section A: Membership shall be amended by substitution of the following statement: *Section A: Membership. Sub-section 5. Discontinuance. Any member who has failed to pay his annual dues by March first of the current financial year shall no longer be entitled to the rights and privileges of membership. He may be restored to good standing by payment of all delinquent dues, but shall automatically forfeit membership in this Association at the end of the second year of such delinquency. He shall be notified by the Secretary-treasurer of the said termination (III. 5, B).*

After suspension of the rules by a unanimous vote, the Secretary-treasurer was ordered to cast the unanimous vote of the Association for the 36 persons whose nominations to membership had been approved by the Council for election to membership. Election completed formally. (List printed elsewhere in these proceedings, see page 781.)

The Secretary-treasurer was directed to thank the many individuals and organizations who contributed so much to the preparations for and the conduct of this general meeting, especially the Rochester Convention Bureau, its chairman, Mr. Allen Doyle, Dr. David F. Mitchell and the other members of the local committee, the University of Rochester, the Eastman Dental Dispensary, and the Sheraton Hotel.

President Hodge then called all the newly elected officers except Dr. Brodie to the front of the speaker's table and duly inducted them into their respective offices claiming and getting their pledge to serve the Association faithfully and earnestly for the ensuing Association year. Finally he introduced the new President, Dr. Allan G. Brodie who then gave his presidential address (p. 717), after which he took the gavel from the retiring President Hodge, called for any last minute item for presentation to the general meeting, and when there appeared to be none, formally adjourned the 1948 general meeting.

C. JOURNAL OF DENTAL RESEARCH

REPORT OF THE PUBLICATION COMMITTEE

Editor: Beginning with Issue Number One of Volume 27, the *Journal* has entered a new period. Its printers and publishers have shown an active

interest in its welfare. The quality of the paper and of the illustrations has been greatly improved. The cooperation of the Managing Editor of the C. V. Mosby Company has simplified your Editor's work and helped to improve the appearance of the *Journal*.

Although the publishers agreed to print approximately one hundred pages per issue, each of the first three issues is well over this total. This expansion is due to inclusion of the Proceedings of the Michigan Dental Caries Conference in these three issues. The C. V. Mosby Company, at our request, agreed to allow up to one hundred fifty extra pages to publish this valuable material.* It is hoped that the precedent set by republication of Gregory's "Origin and Evolution of the Human Dentition" will be followed in this instance.†

The complete contract for the *Journal* is published on pages 126-127 of the April, 1948, issue. The Editor has received copies of one resolution opposed to the present contract and numerous letters from contributors and subscribers in praise of the new publishing arrangements. It is noteworthy that no member of the committee drawing up the adverse resolution communicated with the Editor concerning the contract and that the resolution was circulated before the contract was published.

Your Editor is well pleased with the present publishing arrangement and earnestly hopes that the Association will not repudiate the contract which was approved by the Board of Editors to whom the Association has assigned the duty of conducting the *Journal of Dental Research*.

Business Manager: Expenditures and receipts from January 1 to June 31, 1948, were as follows:

Balance on hand December 31, 1947		$6,392.37
Receipts:		
Back issues of the *Journal*		218.59
Total Receipts		$6,610.96
Disbursements:		
Clerical and miscellaneous	$ 288.00	
Printing	4,967.67	
Stationery and Supplies	135.88	
Postage	67.09	
		$5,458.64
Balance on hand June 1, 1948		$1,152.32

Circulation Manager: Volume 26 was distributed as follows:

I. Domestic (Within the United States)			
Regular Individual Subscriptions	1074		
Membership Subscriptions	505		
Life Subscribers	15		
Sustaining	4		
Student	7		
Libraries	106		
		1711	
II. Foreign			
Regular Individual Subscriptions	209		
Libraries	60		
		269	1980

*Editor's Note: This volume actually contains 808 pages.

†Editor's Note: This has been published as "Dental Caries"—Easlick, K. (St. Louis, The C. V. Mosby Co., 1948).

III. Necessary Copies for *Journal* Operation			
Dr. Wm. J. Gies	1		
Dr. E. H. Hatton	10		
Dr. H. B. G. Robinson	3		
Dr. J. Frank Hall	75		
Exchanges	101		
Complimentary	3		
		193	193
Total copies sent out (Vol. 26)			2173
Stock at press			777
Total press run			2950

REPORT OF THE BOARD OF EDITORS

The Publication Committee reported on the present status of the *Journal* and that it was well satisfied with the present publishing relationships.

After lengthy discussion of the relationships between the Association and the publishers, the Publication Committee was instructed by the Board of Editors to investigate the possibility of replacing the present $1800 received as an annual royalty by a satisfactory substitute and the committee was authorized to modify the contract if such a satisfactory substitute is found.

D. William J. Gies Endowment Fund, Journal of Dental Research

FINANCIAL STATEMENT AS OF JUNE 20, 1948

Compiled by LEUMAN M. WAUGH, D.D.S., Treasurer

This Fund was created, on the initiative of the voluntary Committee on Endowment—organized in New York City in 1937—to insure the continuance of the *Journal of Dental Research* "in full accord with the highest ideals of strictly professional journalism devoted to the advancement of research," to which the *Journal* was dedicated at its establishment in 1919.

I. *Amounts received from Organizations*

(June 14, 1947, to June 20, 1948)

Louisiana State Dental Society	$ 25.00	
Rhode Island State Dental Society	50.00	
		$ 75.00

II. *Amounts received from Individuals*

(June 14, 1947, to June 20, 1948)

$2.63[1]:	F. A. Richmond (1 × $2.63)	$ 2.63	
			2.63
Total contributions 1947-48			$ 77.63

[1]Coupon ($2.25), plus interest ($.38) on Bethany Methodist Hospital Bond, from May 1, 1947 (maturity date) to June 1, 1947 (date when bond was converted to cash).

III. *Interest, Income and Expense (current year)*

No expenses were recorded.

INTEREST TO DATE, JUNE 20, 1948, ON WAR BONDS:

Number of Bonds	Denomination of Bonds	Date Purchased	Interest Accrued During Current Year	
10	$1,000.00	March, 1942	$ 250.00	
22	1,000.00	May, 1942	550.00	
8	1,000.00	July, 1942	104.00	
2	1,000.00	December, 1942	42.00	
1	1,000.00	March, 1943	21.00	
1	25.00	February, 1944	.40	
5	1,000.00	March, 1944	80.00	
2	1,000.00	May, 1944	32.00	
1	1,000.00	July, 1944	13.00	
3	1,000.00	September, 1945	27.00	
2	1,000.00	March, 1946	14.00	
			$1,133.40	$ 1,133.40

Total contributions 1947-48 (Section I and Section II) ---------- $ 77.63

Total addition to the Fund, including accrued interest for the current year ---------- $ 1,211.03

IV. *Summary of the Total Assets: 1937-48*

Total receipts (assets) for the Fund as of June 20, 1948 ---------- $44,858.21

Paid for 56 War Bonds (Section VI) ----------	$41,440.00
Shares of Stock (Section VI)[2] ----------	365.00
Interest accrued during current year ----------	1,133.40
Interest accrued during 1946-47 ----------	1,183.29
Balance ----------	736.52

[2]Bethany Methodist Hospital Bond ($100.00), included in this figure in previous reports, matured and was converted into cash on June 1, 1947. Therefore, it is now part of the cash balance.

V. *Cumulative Summary of Annually Recorded Items of Receipts and Expenditures*

Year	Contributions (Payments)	Earned Interest	Expense	Net Receipts	Cumulative Annual Net Receipts
1937-38	$10.652.50	None	$134.06	$10,518.44	$10,518.44
1938-39	4,748.17	None	None	4,748.17	15,266.61
1939-40	5,693.78	None	None	5,693.78	20,960.39
1940-41	5,190.55	$ 206.78	3.53	5,393.80	26,354.19
1941-42	4,166.35	333.95	None	4,500.30	30,854.49
1942-43	1,766.31	112.19	None	1,878.50	32,732.99
1943-44	3,302.23	334.00	None	3,636.23	36,369.22
1944-45	3,744.45	459.05	None	4,203.50	40,572.72
1945-56	1,144.50	497.17	None	1,641.67	42,214.39
1946-47	249.50	1,183.29	None	1,432.79	43,647.18
1947-48	77.63	1,133.40	None	1,211.03	44,858.21
	$40,735.97	$4,259.83	$137.59	$44,858.21	

VI. *Statement Regarding Investment in War Bonds*

By authorization of the Trustees of the Association, fifty-six War Bonds of Series F (''12-year appreciation bonds''), costing $740 each, have been purchased from the funds in the Endowment Committee's treasury, as of the following dates and serial numbers:

Purchased (10)	March	1942:	M140400F to M140409F, incl.	$ 7,400.00
Purchased (22)	May	1942:	M197811F to M197832F, incl.	16,280.00
Purchased (8)	July	1942:	M237558F to M237565F, incl.	5,920.00
Purchased (2)	December	1942:	M423990F and M423991F	1,480.00
Purchased (1)	March	1943:	M204356F	740.00
Purchased (5)	March	1944:	M750832F to M750836F, incl.	3,700.00
Purchased (2)	May	1944:	M752375F and M752376F	1,480.00
Purchased (1)	July	1944:	M892919F	740.00
Purchased (3)	September	1945:	M649868F to M649870F, incl.	2,220.00
Purchased (2)	March	1946:	M1061926F and 1061927F	1,480.00
				$41,440.00

The payee named on each bond is ''Committee on the William J. Gies Endowment Fund for the *Journal of Dental Research* (an unincorporated body).'' All of these War Bonds are in the custody of the Treasurer of the Committee, in a safety deposit box, Empire Trust Company, 580 Fifth Avenue, New York 19, N. Y., in trust for the Committee.

The contribution of $18.50, listed in Section II of the report for 1943-44 from Dr. Joseph E. Psayala (also mentioned in Section IV of this report), was in the form of a $25 United States War Bond Series F (''12-year appreciation bond''), Q631670F, the payee being ''William John Gies Endowment Fund for the *Journal of Dental Research*.'' It is in the custody of the Treasurer in a safety deposit box, Empire Trust Company, 580 Fifth Avenue, New York 19, N. Y., in trust for the Committee. The bond was purchased in February, 1944.

The Farnsworth Television and Radio Corporation Stock, indicated in Section IV, is also in the custody of the Treasurer of the Committee in a safety deposit box, Empire Trust Company, 580 Fifth Avenue, New York 19, N. Y., in trust for the Committee.

Bethany Methodist Hospital Bond—please refer to footnote 2.

VII. *Summary of Open Accounts Relating to Pledges*

	Pledge	Paid	Balance	
A. Organizations				
Kansas: First District Dental Society	$ 100.00	$ 25.00	$ 75.00	
J. B. Mann Study Club, Washington, D. C.	1,000.00	200.00	800.00	$ 875.00
B. Individuals				
Harry Kaplan	250.00	100.00	150.00	
R. J. Rinehart	200.00	75.00	125.00	275.00
				$1,150.00

Respectfully submitted,

LEUMAN M. WAUGH, Treasurer

E. OFFICERS AND MEMBERS ELECTED

ACTIVE OFFICERS: President-elect—*J. Roy Blayney,* Zoller Memorial Dental Clinic, University of Chicago. Vice-president—*Basil G. Bibby,* Eastman Dental Dispensary. Secretary-treasurer—*Edward H. Hatton,* Northwestern University. Trustee for five years—*H. Trendley Dean,* National Institute of Health. Editor—*Hamilton B. G. Robinson,* Ohio State University. Members of the Publication Committe—*J. Frank Hal',* Business Manager, University of Indiana and *Sumter S. Arnim,* Circulation Manager, University of Texas.

MEMBERS ELECTED: Bethesda, Md.—*Isadore Zipkin,* National Institute of Health and *George W. Ferguson,* Dental Corps, USN. Beverly Hills, Calif.—*Allison G. James.* Birmingham, Ala.—*Samuel Dreizen,* Hillman Hospital. Boston, Mass.—*Finn Brudevold,* Tufts College. Evanston, Ill.—*Donald J. Martin,* Health Department. Great Lakes, Ill.—*Curtiss W. Schantz,* Dental Corps, USN. Houston, Tex.—*Ira T. Telford, Edwin L. Smith,* and *John H. Barr,* University of Texas. Indianapolis, Ind.—*Joseph C. Muhler,* University of Indiana. Jackson Heights, N. Y.—*Basil Soyenkoff,* New York University. Little Rock, Ark.—*Harry J. Clausen,* University of Arkansas. Louisville, Ky.—*Henry M. Wilbur,* University of Louisville. Mexico City—*Samuel Fastlicht.* Minneapolis, Minn.—*Henry B. Clark, Jr.,* University

of Minnesota, and *William A. Jordan,* Minnesota Health Department. New York, N. Y.—*Percy L. Johnson* and *Leon H. Schneyer,* New York University. New Orleans, La.—*Thomas L. Hagan,* U. S. Public Health Service, Philadelphia, Pa.—*Moe B. Markus,* Temple U., and *George G. Stewart,* University of Pennsylvania. Rochester, N. Y.—*Hyman J. V. Goldberg* and *Emmett R. Costich,* University of Rochester. St. Louis, Mo.—*Julius G. Godwin,* St. Louis University. Seattle, Wash.—*Claude R. Baker* and *David B. Law,* University of Washington. Toronto, Canada—*W. J. Linghorne* and *W. G. McIntosh,* Toronto University. Trenton, N. J.—*Neal W. Chilton,* New York University. Washington, D. C.—*Edward O. Shaner,* Carlton. Victoria, Australia—*Albert R. Docking,* University of Melbourne. Holbaek, Denmark—*H. Eggers Lura,* St. Elizabeth's Hospital. London, Eng.—*H. J. Turkheim,* Montevideo. Uruguay—*Ricardo C. Artagaveytia,* Instituto di Higiene Experimental. Dunedin, New Zealand—*Frederick W. Craddock.* Total, 36.

F. MEMBERS VOTING FOR GENERAL OFFICERS

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G. MEMBERS IN ATTENDANCE AT ONE OR MORE SESSIONS, LISTED BY SECTIONS

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Attendance of New Members Elected June 20, 1948—J. H. Barr, Finn Brudevold, H. B. Clark, Jr., F. W. Craddock, E. R. Costich, G. W. Fergson, H. J. V. Goldberg, P. L. Johnson, J. C. Muhler, D. J. Martin. Total, 10. Registered Guests, 132. Total, 270.

SUPPLEMENT

I. International Association for Dental Research

Membership lists, including addresses of North American members and section rolls. This material is printed annually in the December number of the *Journal of Dental Research*.

Compiled by Edward H. Hatton, *Secretary-Treasurer*

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[1]Abbreviations used: I.A.D.R.—International Association for Dental Research: J.D.R.—*Journal of Dental Research*; A.D.A.— American Dental Association.

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